



**DRAFT**  
**2023 ASTROPHYSICS PROBE EXPLORER**  
**(APEX)**

**CRITERIA AND REQUIREMENTS FOR THE**  
**PHASE A CONCEPT STUDY**

**December 20, 2022**

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**DRAFT**  
**2023 ASTROPHYSICS PROBE EXPLORER ANNOUNCEMENT OF**  
**OPPORTUNITY (NNH22ZDA008L)**  
**CRITERIA AND REQUIREMENTS FOR THE**  
**PHASE A CONCEPT STUDY**

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**INTRODUCTION**

As the outcome of the Astrophysics Probe Explorer (APEX) Announcement of Opportunity (NNH22ZDA008L, hereafter, the “AO”) Step-1 competition, NASA is planning on selecting approximately two or three investigations that the Agency will fund to perform concept studies. The concept study for each selected investigation will constitute the investigation’s Concept and Technology Development Phase (Phase A) of the Formulation process as outlined in NPR 7120.5F, *NASA Space Flight Program and Project Requirements*.

Documents available through the Astrophysics Probe Explorer (APEX) Program Library at <https://explorers.larc.nasa.gov/2023APPROBE/programlibrary.html> are intended to provide guidance for selected investigations. This website is hereafter referred to as the Program Library. Note that new documents have been added to the Program Library for this Step-2 acquisition.

Concept studies are intended to provide NASA with more definitive information regarding the cost, risk, and feasibility of the investigations, as well as provide small business subcontracting plans, optional Student Collaborations (SCs), Citizen Science, Science Enhancement Options (SEOs), if proposed, before final selection for implementation.

The versions of NASA documents, also posted in the program library, must be used for consistency regardless of any later versions that may be issued after this criteria and requirements document is released.

The product of a concept study is a Concept Study Report (CSR), to be delivered to NASA approximately nine months after the Concept Study Kick-Off Meeting (see below). This document provides guidelines and requirements for preparing a CSR. All program constraints, guidelines, definitions, and requirements specified in the AO are applicable to the CSR, except as noted herein. Examples of CSR requirements include:

- The PI-Managed Mission Cost (PIMMC) may not increase by more than 20% from that in the Step-1 proposal to that in the CSR, with adjustments as applicable, and in any case, may not exceed the Cost Cap specified in the AO. (See AO Sections 4.3.1 and 7.4.4)
- NASA intends investigations to be implemented as Category 2 projects (per NPR 7120.5F) and with Class C payloads (per NPR 8705.4A, *Risk Classification for NASA*

*Payloads*) with a minimum science mission duration of 5 years. NPR 7120.5F and NPR 8705.4A are available in the Program Library. (See AO Section 4.1.4)

- APEX missions are required to meet the requirements for safety, reliability, and mission assurance in the Explorers safety, reliability, and quality assurance requirements as specified in the *Explorers and Heliophysics Projects Division (EHPD) Program Mission Assurance Requirements (MAR) - Class C* document in the Program Library. (See AO Sections 4.1.2 and 5.2.9)
- Small business subcontracting plans are required, covering Phases B/C/D/E/F. (See AO Section 5.5.1)

Several items that were deferred from Step 1 that must be provided in the CSR include:

- Detailed disposal plan (see AO Section 5.2.8, and Section L.9 of this document)
- Science Enhancement Option and its cost, if proposed (see AO Section 5.1.8)
- Independent Verification and Validation of Software (see AO Section 4.6.1)
- Costing of coordination with Conjunction Assessment Risk Analysis (see AO Section 4.6.4)
- Schedule-based end-to-end Data Management and Archive Plans (see AO Requirements B-28 and B-29, and Section L.5 of this document)
- Demonstration of maximum channel bandwidth (see AO Section 5.2.6.2)
- Discussion of critical event coverage capabilities (see AO Section 5.2.7)
- Non-AMMOS system use and description (see AO Section 5.2.10)
- Descriptions of the Space Systems Protection implementation (see AO Section 5.2.11)
- Ground system data flow diagram (see AO Section 5.2.12)
- Naming of Project Manager (PM) and Project Systems Engineer (PSE) (see AO Section 5.3)
- Detailed discussion of the descope approach (see AO Section 5.3.6)
- Discussion of cost estimate error and uncertainty (see AO Section 5.6.3)
- Requirements for real year dollar costs (see AO Section 5.6.2, Requirement B-13, Requirement B-57, and Requirement B-58)
- Student Collaborations and their cost, if proposed (see AO Section 5.5.2)
- Citizen Science and its cost, if proposed (see AO Section 5.4.4)

Electronic versions of CSRs and all required files, along with images of the original signatures of the Principal Investigator and an official of the PI's institution who is authorized to commit its resources are due to the APEX Program Scientist, Patricia Knezek, by 4 p.m. Eastern time on <<STP 2 DATE>>, by the method specified in Requirement CS-9.

PART I of this document describes the evaluation criteria for CSRs. PART II provides guidelines for preparing CSRs; every requirement in these guidelines must be addressed in the section in which the requirement appears. An explanation and justification must be provided for any requirement that is not fully addressed in the CSR. PART III describes other factors that are not required and will not be evaluated, but will need to be provided by the project shortly after a down-selection.

Phase A contracts for all selected investigations will include a five-month priced option for a Bridge Phase, that will be exercised for the down-selected investigation. The focus of the Bridge Phase will be: 1) participation in the Explorers Program Office project kick-off meeting; 2) work with the Explorers Program Office to negotiate and award the balance of Phase B; 3) other interactions with the Explorers Program Office as necessary, and 4) other project work planned for the first five months of Phase B. A modification will be negotiated during the first four months of Phase B, to cover the remainder of the Phase through KDP-C. For each investigation selected in Step 1, the Explorers Program Office at the NASA Goddard Space Flight Center (GSFC) will negotiate a priced option for the Bridge Phase into the Phase A contracts. After they are notified of the Phase A selection, organizations to be awarded a Phase A contract will receive a Request for Proposal (RFP) for a detailed cost proposal that includes the effort to complete Phase A and as a separately priced option, the Bridge Phase.

Since evaluation of CSRs is a major part of Step 2 in the acquisition process, NASA will assemble an evaluation team of scientific and technical peers to carefully consider each CSR. Because members of this evaluation team may not have reviewed, nor will be provided access to, Step-1 proposals, each CSR must be a self-contained document.

The CSR evaluation process will include visits by the evaluation team to each investigation team's chosen site, to hear oral briefings and, if needed, to receive updates and clarification of material in the CSRs. These briefings will be conducted no earlier than three months following submission of the CSRs; scheduling and expectations for the Site Visits will be addressed at the Concept Study Kick-Off Meeting. NASA may identify significant weaknesses, questions, and requests for information, and ask that the investigation team respond to these either prior to, during, or after the Site Visit. Any additional information provided to NASA by the investigation team will be considered during the evaluation and treated as updates and clarifications to the CSR.

Investigation teams are responsible for the content and quality of their CSRs, Site Visit presentations, and responses to weaknesses and questions, including parts that may be prepared by partner organizations or by any other individual. All assumptions and calculations should be carefully documented in the CSR and agreed to by the PI and their team, to ensure that they are accurate and that they will satisfy NASA requirements. Investigation teams are also responsible for assuring that all requirements specified in Part II of this document are addressed.

As the outcome of Step 2, it is anticipated that the Selection Official, the Associate Administrator of the Science Mission Directorate (SMD) at NASA Headquarters or their designee, plans to continue one investigation into the subsequent phases of mission development for flight and operation. The target date for this continuation decision (*i.e.*, "down-selection") is approximately five months after the CSR's are due to NASA.

For those investigations that are not continued, the contracts will be allowed to terminate without further expense to NASA. Every investigation team will be offered a debriefing of the evaluation of its CSR.

## **PART I - EVALUATION CRITERIA**

The evaluation of CSRs is very similar to the evaluation of Step-1 proposals, as described in Section 7.1 of the AO. The evaluation criteria and their factors, specified in Sections 7.2.1 through 7.2.4 of the AO, apply fully to CSRs. However, all factors related to the probability of mission success and to the realism of the proposed costs to NASA will be considered in greater depth of detail. Additional factors, such as implementation plans for Student Collaborations and small business subcontracting, will also be evaluated. In case of conflict between the AO and the CSR Guidelines, the CSR Guidelines take precedence.

All information relevant to the evaluation will be considered during the evaluation of Step 2 concept studies, including information contained in the CSR, information presented during the Site Visit, and information provided in response to weaknesses and questions.

Each CSR must be a self-contained document and must not refer to information contained in the Step-1 proposal. Except for compliance checking by NASA (*e.g.*, that the PIMMC has not grown by more than 20%) and for determining if re-evaluation of Scientific Merit of the Proposed Investigation is required (as described below), the Step-1 proposals will not be used in the Step 2 evaluation.

The evaluation criteria for the Step 2 evaluation are:

- 1) Scientific Merit of the Proposed Investigation;
- 2) Scientific Implementation Merit and Feasibility of the Proposed Investigation;
- 3) TMC Feasibility of the Proposed Mission Implementation;
- 4) Merit of the Student Collaboration Plan;
- 5) Merit of the Small Business Subcontracting Plan; and
- 6) Merit of the Citizen Science Plan.

### **Scientific Merit of the Proposed Investigation**

The APEX Program Scientist will determine whether any issues that may have emerged in the course of the concept study have resulted in significant changes to the science objectives or other aspects of the proposed Baseline and Threshold Science Missions (see Requirement CS-17 in PART II of this document) in such a manner as to have impacted the basis for the evaluation of the scientific merit of the investigation as determined by the peer review panel for the Step-1 proposal. If there are no significant changes to the proposed investigation that undermine the basis of this rating, the peer review panel rating for scientific merit of the Step-1 proposal will be the rating for scientific merit of the CSR. If there are significant changes, the Program Scientist will convene a peer review panel to re-evaluate the scientific merit of the objectives in light of these changes. The factors for re-evaluating this criterion will be the same as those used for the Step-1 proposal review (Section 7.2.2 of the AO).

### **Scientific Implementation Merit and Feasibility of the Proposed Investigation**

All of the factors defined in Section 7.2.3 of the AO also apply to the evaluation of the CSR. Note that details have been added to some of the subfactors, and new subfactors apply in Step 2.

*New factors and details added to Step-1 AO factor definitions are highlighted using blue italicized text for the evaluation of the CSR.*

Factor B-1. Merit of the proposed mission architecture, instruments and measurement techniques for addressing the science goals and objectives. This factor includes the degree to which the proposed mission will address the goals and objectives; the appropriateness of the selected instruments and mission design for addressing the goals and objectives; and the appropriateness of the mission requirements for guiding development and ensuring scientific success.

Factor B-2. Probability of technical success. This factor includes the maturity and technical readiness of the instruments or demonstration of a clear path to achieve necessary maturity; the adequacy of the plan to develop the instruments within the proposed cost and schedule; the robustness of those plans, including recognition of risks and mitigation plans for retiring those risks; the likelihood of success in developing any new technology that represents an untested advance in the state of the art; the ability of the development team - both institutions and individuals - to successfully implement those plans; and the likelihood of success for both the development and the operation of the instruments within the mission design. *This factor includes assessment of technology readiness, heritage, environmental concerns, accommodation, and complexity of interfaces for the instrument design.*

Factor B-3. Data adequacy, analysis, and archiving. This factor includes the degree to which the proposed mission and instruments can provide the quality and quantity of data necessary to complete the investigation and meet the proposed science objectives. Additionally, it includes the merit of data analysis plans, including the fidelity of physical models required to connect the measurements to the science objectives; and plans for archiving, to preserve data and analysis of value to the science community. Considerations include planning and budget adequacy, with plans for well-documented, high-level data products and software usable to the entire science community; adequate resources for physical interpretation of data; reporting scientific results in the professional literature (e.g., refereed journals); and timely release of the data to the public domain.

Factor B-4. Science resiliency. This factor includes both developmental and operational resiliency. Developmental resiliency includes the approach to descoping the Baseline Science Mission to the Threshold Science Mission in the event that development problems force reductions in scope. Operational resiliency includes the ability to withstand adverse circumstances, the capability to degrade gracefully, and the potential to recover from anomalies in flight.

Factor B-5. Probability of science team success. This factor will be evaluated by assessing the experience, expertise, and organizational structure of the science team and the mission design in light of any proposed instruments. The role of each Co-Investigator (Co-I) will be evaluated for necessary contributions to the proposed investigation; the inclusion of Co-Is who do not have a well-defined and appropriate role may be cause for downgrading during evaluation. The inclusion of career development opportunities to train the next generation science leaders will also be evaluated.



Factor B-6. Merit of the proposed mission architecture, instruments, and measurement techniques for addressing the potential General Observer or Guest Investigator science. This factor includes how well the anticipated measurements for the PI-led proposed science would demonstrate the capability of the Observatory to successfully perform the potential General Observer or Guest Investigator program.

Factor B-7. Merit of the Diversity and Inclusion Plan. This factor includes the alignment of the proposal with NASA's core value of inclusion, the effectiveness of the plan in achieving its objectives in the context of mission success, the inclusion of mentoring and career development opportunities to train the next generation of science leaders, and transparency of annual reporting to NASA.

*Factor B-8. Maturity of proposed Level 1 science requirements and Level 2 project requirements. This factor includes assessment of whether the Level 1 science requirements are mature enough to guide the achievement of the objectives of the Baseline Mission and the Threshold Mission, and whether the Level 2 requirements are consistent with the Level 1 requirements. The Levels 1 and 2 requirements will be evaluated for whether they are stated in unambiguous, objective, quantifiable, and verifiable terms that do not conflict and for whether they are traceable to the science objectives. They will be evaluated for the adequacy, sufficiency, and completeness, including their utility for evaluating the capability of the instruments and other systems to achieve the mission objectives. The Level 1 science requirements and Level 2 project requirements will be assessed to determine whether the requirements are ready, upon initiation of Phase B, to be placed under configuration control with little or no expected modifications for the lifecycle of the mission.*

*Factor B-9. Scientific Implementation Merit and Feasibility of any Science Enhancement Options (SEOs), if proposed. This factor includes assessing the potential and appropriateness of the selected activities to enlarge the science impact of the mission and the costing of the selected activities. Although evaluated by the same panel as the balance of Scientific Implementation Merit and Feasibility factors, this factor will not be considered in the overall criterion rating. The panel will provide comments to NASA on their findings for this factor.*

## **TMC Feasibility of the Proposed Mission Implementation**

All of the factors defined in Section 7.2.4 of the AO apply to the evaluation of the CSR. All of these factors are interpreted as including an assessment as to whether technical, management, and cost feasibility are at least at a Phase A level of maturity. *New factors and details added to Step-1 AO factor definitions are highlighted using blue italicized text for the evaluation of the CSR.*

Note that the risk management aspects of the Step-1 AO Factor C-4, Adequacy and robustness of the management approach and schedule, including the capability of the management team, have been removed from Factor C-4 and included in a new evaluation Factor C-6, Adequacy of the risk management plan. The text that is deleted from Step-1 AO Factor C-4 is indicated by the blue strike-through and is the basis for Factor C-6.

Factor C-1. Adequacy and robustness of the instrument implementation plan. The maturity and technical readiness of the instrument complement will be assessed, as will the ability of the instruments to meet mission requirements. This factor includes an assessment of the instrument design, accommodation, interface, heritage, and technology readiness. This factor includes an assessment of the instrument hardware and software designs, heritage, and margins. This factor includes an assessment of the proposer's understanding of the processes, products, and activities required to accomplish development and integration of the instrument complement. This factor also includes adequacy of the plans for instrument systems engineering and for dealing with environmental concerns. This factor includes an assessment of plans for the development and use of new instrument technology, plans for advanced engineering developments, *and the adequacy of backup plans* to mature systems within the proposed cost and schedule when systems having a TRL less than 6 are proposed.

Factor C-2. Adequacy and robustness of the mission design and plan for mission operations. This factor includes an assessment of the overall mission design and mission architecture, the spacecraft design and design margins (including margins for launch mass, delta-v, and propellant), the concept for mission operations (including communication and navigation/tracking/trajectory analysis, *operational scenarios and timelines for each mission phase, operations team roles and responsibilities, and GI/GO interfaces and operational coordination*), and the plans for launch services. This factor includes mission resiliency - the flexibility to recover from problems during both development and operations - including the technical resource reserves and margins, system and subsystem redundancy, and reductions and other changes that can be implemented without impact to the Baseline Science Mission.

Factor C-3. Adequacy and robustness of the flight systems. This factor includes an assessment of the flight hardware and software designs, heritage, and margins. This factor includes an assessment of the plans, *processes*, products, and activities required to accomplish maturation, development, integration and verification of all elements of the flight system. This factor includes an assessment of the adequacy of all elements of flight system resiliency, including flight software/hardware fault management, system and subsystem redundancy, and hardware reliability. *This factor includes an assessment of the adequacy of the plans for spacecraft systems engineering, qualification, verification, mission assurance, and launch operations.* This factor includes the plans for the development and use of new technology, plans for advanced engineering developments, and the adequacy *of backup plans*, to ensure success of the mission when systems having a TRL less than 6 are proposed. The maturity and technical readiness of the spacecraft, subsystems, *and operations systems* will be assessed. *The adequacy of the plan to mature systems within the proposed cost and schedule, the robustness of those plans, including recognition of risks and mitigation plans for retiring those risks, and the likelihood of success in developing any new technologies* will be assessed.

Factor C-4. Adequacy and robustness of the management approach and schedule, including the capability of the management team. This factor includes: the adequacy of the proposed organizational structure *and WBS*; the management approach *including project level systems engineering*; the roles, commitment, qualifications, and experience of *the PI, PM, PSE, other* named Key Management Team members, the implementing organization and known

partners; the spaceflight experience of *the PI, PM, PSE, and all other* named Key Management Team members; and *relevant performance of the* implementing organization and known partners against the needs of the investigation; the prior working relationship of the implementing organization and known partners; the commitments of partners and contributors; and the team's understanding of the scope of work covering all elements of the mission, including contributions. This factor also includes assessment of elements such as the relationship of the work to the project schedule, the project element interdependencies, the associated schedule margins, and an assessment of the likelihood of meeting the proposed launch readiness date. *Also evaluated under this factor are the proposed project and schedule management tools to be used on the project.*

Factor C-5. Adequacy and robustness of the cost plan, including cost feasibility and cost risk. This factor includes elements such as cost, cost risk, cost realism, and cost completeness including assessment of the basis of estimate, the adequacy of the approach used to develop the estimated cost, *the methods and rationale used to develop the estimated cost*, the discussion of cost risks, the adequacy and allocation of cost reserves by phase, and *the team's understanding of* the scope of work (covering all elements of the mission, including contributions). The adequacy of the cost reserves and understanding of the cost risks will be assessed. This factor also includes an assessment of the proposed cost relative to estimates generated by the evaluation team using parametric models and analogies. *Also evaluated under this factor are the proposed cost management tools to be used on the project.*

Factor C-6. Adequacy of the risk management plan. The adequacy of the proposed risk management approach will be assessed, including any risk mitigation plans for new technologies; any long-lead items; and the adequacy and availability of any required manufacturing, test, or other facilities. *The approach to any proposed descoping of mission capabilities will be assessed against the potential science impact to the proposed Baseline Science Mission.* The management of the risk of contributed critical goods and services will be assessed, including the plans for any international participation, the commitment of partners and contributors, as documented in Letters of Commitment, and the technical adequacy of contingency plans, where they exist, for coping with the failure of a proposed cooperative arrangement or contribution; *when no mitigation is possible, this should be explicitly acknowledged. The stability and reliability of proposed partners, and the appropriateness of any proposed contribution, is not assessed as a management risk but will be assessed by SMD as a programmatic risk element of the investigation.*

Factor C-7. *Ground systems. This factor includes an assessment, including heritage and planned new development, of the proposed operations facilities, hardware and software (i.e., those for mission operations and science operations), and a telecommunications analysis, ground network capability and utilization plan, and navigation plans. This includes assessment of the GO plans.*

Factor C-8. *Approach and feasibility for completing Phase B. The completeness of Phase B plans and the adequacy of the Phase B approach will be assessed. This assessment will include evaluation of the activities/products, the organizations responsible for those activities/products, and the schedule to accomplish the activities/products.*

Any impact to the primary mission due to the inclusion of SC(s), CS, and/or SEO(s) will also be included in the factors above. The AO specifies that the Concept Study Report shall demonstrate that the proposed SC is clearly separable from the proposed Baseline and Threshold Science Missions; will not increase the mission development risk; and will not impact the science investigation in the event that the SC is not funded, fails during flight operations, or encounters technical, schedule, or cost problems during development. Details of the SC(s), CS, and SEO(s) evaluations are given in Sections E.7 and H.

The panel evaluating the “TMC Feasibility of the Proposed Mission Implementation” will also provide comments to NASA regarding the extent to which the proposed investigation provides career development opportunities to train the next generation of engineering and management leaders. While these comments will not be considered in the evaluation, they may be considered during selection.

### **Merit of the Student Collaboration, Small Business Subcontracting, and Citizen Science Plans**

The following are new evaluation factors that are not described in the AO and therefore were not evaluated for Step-1 proposals. These factors will be evaluated for CSRs.

There is no minimum and no maximum allowable cost for a SC. NASA is providing a SC incentive that is defined to be \$10M FY2023. The proposed cost of the SC, up to the SC incentive, is considered outside of the PIMMC. If the SC costs more than the student collaboration incentive, then the rest of the cost of the SC must be within the PIMMC. The SC incentive as an addition to the mission’s implementation, is not available to solve mission cost overrun issues. The SC provides no cost savings to a NASA investigation.

Merit of the Student Collaboration, if proposed. This factor will include an assessment of whether the scope of the SC follows the guidelines in Section 5.5.2 of the AO. The criteria to be used to evaluate the SC component and a discussion of those criteria are described in SPD-31 available through the Program Library.

To address the merit evaluation, SC proposals are required to include appropriate plans and budgets for evaluation, participant recruitment and retention, mentoring and oversight of students to maximize their learning and describe Research & Development (R&D) conduct, particularly design and development of flight systems; assembly, integration and test; and mission operations and data analysis that enhances, without interference, the mission’s success.

Merit of the Small Business Subcontracting Plans. This factor will be evaluated on the participation goals and quality and level of work performed by small business concerns overall, as well as that performed by the various categories of small business concerns listed in FAR 52.219-9.

Merit of the Citizen Science, if proposed. This factor will include an assessment of whether the scope of the CS follows the guidelines in Section 5.4.4 of the AO. The criteria to be used to evaluate the CS component and a discussion of those criteria are described in SPD-33 available through the Program Library.

## **Weighting of Criteria**

The percent weighting indicates the approximate relative significance of each evaluation criterion in the Selection Official's consideration:

- Scientific merit of the proposed investigation: approximately 20%;
- Scientific implementation merit and feasibility of the proposed investigation: approximately 30%; and
- TMC feasibility of the proposed mission implementation: approximately 50%.

Quality of plans for Small Business Subcontracting, an optional Student Collaboration, if proposed, and optional Citizen Science, if proposed, will be evaluated as separate factors and considered during the selection process.

## **Additional Selection Factors**

At the continuation decision (*i.e.*, the final down-selection), it may be necessary for the Selection Official to consider NASA budget changes and/or other programmatic factors, including but not limited to, career development opportunities to train the next generation of science, engineering and management leaders; changes in scientific mandates, national priorities, and budgetary forecasts that were not evident when the AO was issued. The PIMMC, as well as other programmatic factors, may be additional selection factors.

## **PART II – CONCEPT STUDY REPORT OUTLINE AND REQUIREMENTS**

Successful implementation of an APEX investigation demands that the investigation be achievable within established constraints on cost and schedule. The information requested in PART II of this document will enable the evaluation team to assess how well each investigation team understands the complexity of its proposed investigation, its technical risks, and any weaknesses that will require specific action during Phase B. Investigation teams are cautioned that omissions or inaccurate or inadequate responses to any of the following requirements will negatively affect the overall evaluation.

**Requirement CS-1** A CSR shall be written in English and shall employ metric (SI) and/or standard astronomical units, as applicable. It shall contain all data and other information that will be necessary for scientific and technical evaluations; provision by reference to external sources, such as Internet websites, of additional material that is required for evaluation of the CSR is prohibited.

**Requirement CS-2** Page size shall be either American standard 8.5 x 11 inches or European standard A4. Foldout pages (11 x 17 inches or A3) may be employed at the proposer's discretion, but see Requirement CS-4 for assessment of foldout pages against the page limit.

**Requirement CS-3** Text shall not exceed 5.5 lines per vertical inch (6.5 lines per 3 vertical centimeters) and page numbers shall be specified. Margins at the top, both sides, and bottom of each page shall be no less than 1 inch if formatted for 8.5 x 11 inch paper; no less than 2.5 cm at

the top and both sides, and 4 cm at the bottom if formatted for A4 paper. Single-column or double-column formats are acceptable for text pages. Fonts for text and figure captions shall be no smaller than 12-point (*i.e.*, no more than 15 characters per horizontal inch; six characters per horizontal centimeter). There is no minimum requirement for fonts used within figures and tables, but all text in figures and tables shall be legible; fonts smaller than 8-point are often illegible.

Requirement CS-4 CSRs shall conform to the page limits specified in the CSR *Structure and Page Limits* table. A page quota higher than that in the Step-1 proposal has been allotted to accommodate an expected greater maturity of detail. Three extra pages each are allotted for each additional separate, non-identical science instrument; two extra pages are allotted for each additional separate, non-identical flight element. The total number of such extra pages shall not exceed a maximum of 10 extra pages regardless of the number of science instruments and flight elements. Different instruments on identical spacecraft will only be allotted extra pages for additional non-identical science instruments; no extra pages will be allotted for the resulting additional non-identical flight elements. Six extra pages are allotted each Science Enhancement Option (SEO). Six extra pages each are allotted for the SC and/or the CS if one is proposed. Pages allocated for the proposed SC, CS, and/or SEO shall not be used for any other purpose. Every side of a page upon which printing would appear will count against the page limits unless specifically exempted. Each foldout page will count as two pages against the page limits unless specifically exempted (*e.g.*, schedule foldouts; cost tables required in Sections I and J).

<b>CSR Structure and Page Limits</b>	
<b>Section</b>	<b>Page Limits</b>
A. Cover Page and Summary Information	No page limit, but be brief
B. Fact Sheet and Executive Summary	2 pages for Fact Sheet, and 6 pages for Executive Summary
C. Table of Contents	No page limit
D. Science Investigation (changes from Step 1 highlighted)	39 including up to 5 pages for GO/GI
E. Science Implementation (including SEOs and CS, if proposed) F. Mission Implementation G. Management H. Other Factors to be Evaluated, including SCs I. Preliminary Design and Technology Completion (Phase B) Plan	130 pages; plus 3 pages for each additional, separate, nonidentical instrument*; plus 2 pages for each additional flight element*; plus 6 pages for SC if one is proposed**; plus 6 pages for Citizen Science if proposed**; plus 6 pages for SEO if proposed**; not including schedule foldouts
J. Cost Proposal [Optional Volume 2] K. Justification and Cost Proposal for optional SEO, if applicable	No page limit, but data must be presented in formats described; be brief

<p>L. Appendices (no other appendices permitted)</p> <p>L.1 Letters of Commitment</p> <p>L.2 Relevant Experience and Past Performance</p> <p>L.3 Resumes</p> <p>L.4 Phase B Contract Implementation Data [Optional Volume 2]</p> <p>L.5 Data Management Plan</p> <p>L.6 Any Incentive Plan(s)</p> <p>L.7 Technical Content of Any International Agreements</p> <p>L.8 International Participation Plans</p> <p>L.9 Limiting the Generation of Orbital Debris and End of Mission Plan</p> <p>L.10 Compliance with Procurement Regulations by NASA PI Proposals</p> <p>L.11 Master Equipment List</p> <p>L.12 Heritage</p> <p>L.13 Classified Materials***</p> <p>L.14 Diversity and Inclusion Plan</p> <p>L.15 Small Business Subcontracting Plan</p> <p>L.16 Additional Cost Data to Assist Validation [Optional Volume 2]</p> <p>L.17 Science Change Matrix</p> <p>L.18 Communications Design Data</p> <p>L.19 Space Systems Protection</p> <p>L.20 Cybersecurity</p> <p>L.21 Draft Mission Definition Requirements Agreement</p> <p>L.22 Draft MAIP and MAR Compliance Matrix</p> <p>L.23 Justification for the use of non-AMMOS MOS/GDS</p> <p>L.24 Acronyms and Abbreviations</p> <p>L.25 References and Management Standards List</p>	<p>No page limit, but small size encouraged.</p> <p>*** Submitted separately.</p>
<p>* Total extra pages is limited to 10 as described in Requirement CS-4 regardless of the number of science instruments and flight elements.</p> <p>** Pages allocated for the proposed SCs or SEOs or Citizen Science shall not be used for any other purpose.</p> <p>*** Submitted separately</p>	

**Requirement CS-5** Electronic CSRs shall be unlocked, bookmarked, searchable Adobe Portable Document Format (PDF) files composed of the main CSR, all tables, and all applicable CSR appendices (see Section L of this document). A CSR shall consist of no more than two volumes, divided into readily identifiable sections: each file should be no larger than 60MB for ease of display and navigation. If two volumes are submitted, the second volume shall consist of the cost section (section J) and any cost appendices (*e.g.*, L.4 and L.16) and the first volume shall consist of the remainder of sections A-L. Images (*e.g.*, figures and scans) shall be converted into machine-encoded text using optical character recognition. Audio, video, or embedded animations shall not be included. Materials identified as subject to U.S. export laws and regulations, marked in accordance with Section 5.8.3 of the AO, shall be redacted into separate versions of files that are collected in a Redacted folder. Links to other parts of the CSR are permitted, but links to



materials outside of the CSR are not. In addition to the PDF submission, the electronic files listed below shall also be provided as part of the electronic submission.

- Cost Tables in MS-Excel format (See Section J of this document)
- Schedule in MS-Project format (Requirement CS-47)
- Final list of CSR participants in MS-Excel format (Requirement CS-6)
- Fact Sheet in PDF format (Requirement CS-13)
- Trajectory file(s), if applicable (Requirement CS-33 and Requirement CS-34)
- MEL in MS-Excel format (Requirement CS-106)
- Program and Project Management Standard References (Requirement CS-123)
- All cost files in electronic format (See Section L.16 of this document)

**Requirement CS-6** Provide a list of the individuals who have participated in the concept study (*e.g.*, individuals who worked on the CSR, any CSR contributor, Red Team member, reviewer, *etc.*) and/or whom you are proposing to provide work should the mission be down-selected. Additionally, provide a list of all organizations named in the CSR, or providing developmental or research services, including the lead organization, subcontractors, vendors and contributing organizations who have an interest in the mission. Provide a draft list of the participants as a Microsoft Excel spreadsheet document to the point-of-contact (AO Section 6.1.5) three months prior to the due date of the CSR. Use the Microsoft Excel spreadsheet template that has been posted to the Program Library. This list is to be updated and a final revision shall be included in a separate electronic file with the CSR submission.

The purpose of this requirement is to avoid placing people on the CSR evaluation team who have conflicts of interest. One of the objectives of this requirement is to obtain a list of organizations and individuals who would otherwise be unknown to NASA as having or causing a conflict, *e.g.*, independent consultants or consulting organizations who helped with the CSR, or academic colleagues who were Red Team members for the CSR.

**Requirement CS-7** Create a separate document that contains a table with all of the requirements (Requirement CS-1 through Requirement CS-123) and the page, section, or table number that is the main place in the CSR where the requirement is addressed. Provide this table as a PDF document to the point-of-contact for the AO by email no later than seven calendar days after the CSRs are due.

**Requirement CS-8** If the science investigation (including but not limited to the science goals and objectives) provided with the Step-1 proposal has changed as a result of the concept study, the changes from the original proposal's science investigation section shall be clearly identified in the CSR.

**Requirement CS-9** The CSR and all required files shall be submitted electronically via NASA's Box service. The CSR submittal deadline is specified in the Introduction section. Electronic submission requires the utilization of the NASA Box service, which is Federal Information Processing Standards (FIPS) 140-2 certified for Data-in-Transit (DIT) and Data-at-Rest (DAR). To submit CSRs through Box, investigation teams must provide an email list of no more than three (3) individuals requiring access to Box to submit proposals. This email list must

be provided to the POC no less than seven calendar days before the CSRs are due. Individuals on the list will then receive an emailed invitation with a secure link to Box from NASA. Investigation teams are encouraged to submit a test file using the secure link to Box to ensure functionality prior to CSR submittal.

CSRs written in their entirety by non-government institutions are not mandated to follow CUI marking instructions. However, CSRs that are written fully or partially by government institutions are required to include CUI markings. For those CSRs, it is mandatory to include a banner marking at the top of each page that contains CUI, to alert the reader. For example, pages with export-controlled information would get a “CUI//SP-EXPT” banner. Though not required except for NASA Export Controlled information, portion marking is a highly encouraged and can be accomplished by including a red bordered box, as shown in the document CUI\_Portion\_Marking\_Sample.pdf in the Program Library. Portion marking can also be done according to NASA CUI Handbook, page 11 ([https://cset.nasa.gov/wp-content/uploads/2021/05/ITS-HBK-CUI\\_v1.0.0.pdf](https://cset.nasa.gov/wp-content/uploads/2021/05/ITS-HBK-CUI_v1.0.0.pdf)).

The required uniform format and contents of the CSR are detailed below. Failure to follow this outline may impede the evaluation process.

## **A. COVER PAGE AND SUMMARY INFORMATION**

**Requirement CS-10** A Graphic Cover Page and Summary Information, prepared as directed below, shall preface every CSR. These pages will not be counted against the page limits.

**Requirement CS-11** The Graphic Cover Page shall contain, at a minimum, the following information and elements displayed on the cover page of the CSR:

- The investigation title;
- The name of the proposing organization;
- The name of the PI;
- The name and title of an official who is authorized to commit the proposing organization through the submission of the CSR.

**Requirement CS-12** The following Summary Information shall be included in this Section:

*Names and institutions of all participants in the investigation;  
The Enhanced PI-Managed Mission Cost of the investigation (\$FY23);  
The proposed contributions and contributing organizations, and  
A summary of the investigation, not to exceed 300 words. The Proposal Summary must not contain proprietary or confidential information that the submitters wish to protect from public disclosure.*

Per Requirement 94 in Section 5.8.3 of the AO, if the proposal contains export controlled material, the following Export Controlled Material Statement shall be prominently displayed in Section A of the proposal (following the Proposal Summary Information):

“The information (data) contained in [insert page numbers or other identification] of this proposal is (are) subject to U.S. export laws and regulations. It is furnished to the Government with the understanding that it will not be exported without the prior approval of

the proposer under the terms of an applicable export license or technical assistance agreement. The identified information (data) is (are) printed in a red font and figure(s) and table(s) containing the identified information (data) is (are) placed in a red-bordered box.”

Proposers should be aware that the evaluators of Scientific Implementation Merit and Feasibility (Criterion B) will review a version of the CSR in which any export controlled material has been redacted.

## **B. FACT SHEET AND EXECUTIVE SUMMARY**

Requirement CS-13 Every CSR shall include a Fact Sheet that provides a brief summary of the investigation. The Fact Sheet shall not exceed 2 pages in length. Information conveyed on this Fact Sheet shall include:

- Science objectives (including the importance of the science to the program science goals);
- Mission overview;
- Instrument complement;
- Key spacecraft characteristics;
- Mission management and participating organizations (including teaming arrangements and all named key personnel);
- Schedule summary;
- The proposed PIMMC in Real Year dollars and in Fiscal Year 2023 dollars (FY23\$) from Cost Table Template 1; and
- The proposed Total Cost, including a breakdown of any contributed costs by contributing organization, in RY\$ and in FY23\$ from Cost Table Template 2.

Requirement CS-14 The Executive Summary shall summarize the contents of the CSR and shall include an overview of the proposed baseline investigation, including its scientific objectives, technical approach, management plan, cost estimate, CS if proposed, SC if proposed, and small business subcontracting plans. The Executive Summary shall not exceed 6 pages in length.

## **C. CSR TABLE OF CONTENTS**

Requirement CS-15 The CSR shall contain a Table of Contents that parallels the outline provided in Sections D through L below. A separate index of figures and tables shall also be included.

See the *CSR Structure and Page Limits* table above for page limits on Sections D through L.

## **D. SCIENCE INVESTIGATION**

Requirement CS-16 The Science Investigation section shall describe the science investigation as specified by Requirements B-15 through B-22 in Appendix B of the AO. If there are no changes from the Step-1 proposal, this section shall be reproduced identically from the Step-1 proposal, with a statement that there have been no changes. Such a statement may be inserted before the first page of this section or it may be included in Appendix L.17 of the CSR. The

Science Investigation section shall not exceed 39 pages in length including up to 5 pages for GO/GI discussion.

**Requirement CS-17** Any changes to the Baseline and Threshold Science Missions defined in the Step-1 proposal shall be identified and the rationale for the change(s) provided, including changes to the potential scientific value of GO/GI programs. Such changes to the science mission shall be highlighted in bold or a color with column marking for easy identification. In addition, a change matrix showing the original (proposed) science objective(s), any new or revised science objective(s), rationale for the change(s), and location(s) within the CSR is required as an appendix (see Section L.17 of this document). Corrections (*e.g.*, typos and errors) and nominal updates (*e.g.*, revised references, clarified sentences) to this section, that do not constitute a change to the proposed science mission (*i.e.*, no change to science mission objectives, requirements, implementation details, measurements and data, *etc.*) are not required to be individually identified and tracked; however, a summary of such changes shall be provided.

## **E. SCIENCE IMPLEMENTATION (including Science Enhancement Options if any)**

### **E.1 Level 1 Science Requirements and Level 2 Project Requirements**

The Level 1 requirements identify the mission, science, and programmatic requirements as well as constraints imposed on the project. Consistent with NPR 7120.5F, both baseline and threshold requirements are to be described. Baseline science requirements are the mission performance requirements necessary to achieve the full science objectives of the mission. Threshold science requirements are those mission performance requirements necessary to achieve the minimum science acceptable for the investment.

The Level 1 requirements (referred to as program requirements in NPR 7120.5F) and Level 2 project requirements specify requirements and constraints on science data collection, mission and spacecraft performance, prime mission lifetime, budget, schedule, launch vehicle, and any other requirements or constraints that need to be controlled. The Level 2 requirements flow down from the Level 1 requirements: for example, Level 2 science requirements must describe the data products that would be needed to complete the Level 1 science requirements. The Level 1 requirements provide the criteria to be used to evaluate whether a project should be called for a termination review if it appears it might fail to meet its requirements. Examples of Level 1 science requirements can be found within the Program Level Requirements Appendix (PLRA) documents in the Program Library, along with presentation slides on Level 1 and Level 2 requirements given at the PI Masters Forums (<https://soma.larc.nasa.gov/pi-masters-forums/>).

**Requirement CS-18** The CSR shall provide a set of proposed Level 1 science requirements that will achieve the objectives of the Baseline Science Mission. Both Baseline Science Requirements and Threshold Science Requirements shall be identified. The Level 1 science requirements of the investigation, as agreed to by the PI, PM, PSE and other key personnel, shall be unambiguous, quantifiable, objective, verifiable, and traceable to the mission objectives. CSRs shall provide Level 2 project requirements to guide the design and development of the mission. Lower level requirements shall be provided to the extent that they are known and necessary to explain and justify the design concept including instrument capability, instrument performance, and other aspects of the system architecture that enable the accomplishment of the

mission science objectives. State each requirement in unambiguous, objective, quantifiable, and verifiable terms. Requirements shall not conflict with each other. The Level 2 requirements shall be listed in Appendix L.21, Draft Mission Definition Requirements Agreement (MDRA).

## E.2 Science Mission Profile

Requirement CS-19 This section shall discuss the science observing profile, including all mission-relevant parameters, such as orbit, navigation accuracy, operational time lines (including observing periods, data transmission periods and techniques, and time-critical events), *etc.* The science observation strategy shall also be described in sufficient detail to understand the complexity of science operations, *i.e.*, are the operations regular re-iteration of data collection sequences, thereby establishing a routine flow, or are there numerous, uniquely planned events thereby requiring repeated planning, testing, and upload cycles. The observation planning and decision-making processes, including any potential GO program, if appropriate, shall be outlined including any priorities assigned to specific observations or measurements and any plans to update the observing strategy based on early observations. The schedule and workforce associated with science planning shall also be described. If science operations involve an ebb and flow of personnel to reduce costs during cruise or “quiet” phases, describe plans for maintaining sufficient trained personnel and for how they will be moved off and then back on the project. The manner in which the proposed investigation objectives, selected instruments, and measurement requirements drive the proposed mission design and operations plan shall be included in this discussion.

## E.3 Instrumentation

Requirement CS-20 This section shall describe the instrumentation and the rationale for its selection. It shall identify instrument systems (*i.e.*, individual instruments), instrument subsystems, and instrument components, and sample collection and preservation system as applicable, including their characteristics and requirements, and indicate items that are proposed for development, as well as any existing instrumentation or design/flight heritage. It shall provide a clear understanding of how the concept will provide the required data, show how it can be accommodated by the spacecraft, demonstrate that instruments have the necessary unobstructed fields-of-view over the measurement period required, describe the technology readiness levels and the approach to bring each instrument to technology readiness level (TRL) 6 at Preliminary Design Review (PDR). If no development plan is needed, the reasons for this shall be explicitly stated and the rationale shall be described. A preliminary description of each instrument design, with a block diagram showing the instrument subsystems and components, and their interfaces, along with a description of the estimated performance of the instrument, shall be included. These performance characteristics (which shall be considered as requirements on the flight system) shall include mass, power, volume, data rate(s), thermal, pointing (such as control, stability, jitter, drift, accuracy, *etc.*), spatial and spectral resolution, observable precision, retrieved parameter sensitivity and accuracy, and calibration requirements. This section shall demonstrate that the instrumentation can meet the measurement requirements, including factors such as retrieval results for each remote sensor, error analysis of the information in all sensors, vertical and horizontal resolution, signal-to-noise (S/N) calculations, *etc.* It shall also discuss environmental effects, such as radiation, temperature, and contamination, on each instrument’s measurement capabilities as a function of mission time.

Requirement CS-21 The following information shall be provided for each science instrument proposed:

- Mass (include lower level breakouts);
- Viewing direction(s) in body coordinates;
- Pointing accuracy and stability requirements;
- Operational modes;
- Operational mode timeline;
- Data demand for each instrument operational mode;
- Onboard data processing and storage required from spacecraft;
- Power demand for each instrument operational mode including peak, average, and stand-by power;
- Instrument thermal control capability;
- Applicable instrument diagrams (*e.g.*, optical path); and
- Characteristics of relevant instrument components (*e.g.*, listing of size of optics) in the MEL.

#### E.4 Data Sufficiency

Requirement CS-22 This section shall discuss the quality and quantity of data to be generated by each instrument, as they relate to the proposed science investigation goals and objectives. The flow-down from science investigation goals to measurement objectives and instrument performance shall be stated clearly and supported by quantitative analysis. The section shall demonstrate the degree to which the proposed instruments and mission can provide the necessary data, and demonstrate the sufficiency of the data gathered to complete the PI-led scientific investigation (within the GTO allocation if applicable).

Requirement CS-23 If your mission requires NASA High-End Computing (HEC) resources, the CSR shall state the: 1) requirements, by year, for computing in the “standard billing units” (SBUs); 2) data storage need in Terabytes, by year; 3) explanation of the need to use this capability. You do not need to submit a letter of support. The general HEC webpage is at <https://hec.nasa.gov>, and SBU Conversion Factors may be found at <https://www.hec.nasa.gov/user/policies/sbus.html>. Costs associated with HEC utilization will not count against the PIMMC.

#### E.5 Open Science and Data Management Plan

As a Federal agency, NASA is making a long-term commitment to building an inclusive open science community over the next decade. Open-source science is a commitment to the open sharing of software, data, and knowledge as early as possible in the scientific process. Thus, it is NASA’s intent that all knowledge developed under awards resulting from this solicitation be shared broadly, and to be compliant with SPD-41a, *the Scientific Information Policy for the Science Mission Directorate*. This includes the expectation that there shall be no period of exclusive access to Mission data. A period after the data have been obtained may be allowed for activities such as calibration and validation of the data. This period shall be as short as possible and shall not exceed six months.

Requirement CS-24 A schedule-based end-to-end Open Science and Data Management Plan, including approaches for the release of peer-reviewed publications, the release of the science data that underlie the results and findings in peer-reviewed publications, the release of scientifically useful software, and the archiving of all science products shall be described here and a draft Open Science and Data Management Plan shall be provided in Appendix L.5 (see Requirement CS-98). The plan shall:

- Include approaches for data retrieval, validation, preliminary analysis, image processing, calibration, correction, and archiving;
- Identify science products (*e.g.*, flight data, ancillary or calibration data, theoretical calculations, higher order analytical or data products, laboratory data, *etc.*), including a list of the specific data products, and the individual team members responsible for the data products;
- Identify the appropriate NASA data archive and the formats and standards to be used. Mission data must be made available through one of the following: the High Energy Astrophysics Science Archive Research Center (HEASARC), the Mikulski Archive for Space Telescopes (MAST), or the Infrared Science Archive (IRSA);
- Include an estimate of the raw data volume and a schedule – including the data latency by product – for the submission of raw and reduced data, to the data archive, in physical units accessible to the science community, as well as required calibration information;
- Demonstrate allocation of sufficient resources (cost, schedule, workforce, computational) for archiving as well as for preliminary analysis of the data by the Project Science Team, publication of the results in refereed scientific journals, as well as for the development and release of any new or enhanced scientifically useful algorithms, software, or other tools.

## E.6 Science Team

Requirement CS-25 This section shall identify each key member of the science team and their roles and responsibilities. Resumes or curricula vitae of science team members shall be included as appendices to the CSR. The role of PI and each Co-investigator (Co-I) shall be explicitly defined, the necessity of that role shall be justified, and the funding source (NASA or contributed) shall be noted. The role of each collaborator shall be described.

Requirement CS-26 A summary table shall be included, with columns for 1) PI, Co-I or Collaborator name; 2) their roles and responsibilities on the mission; and 3) their time commitment, in FTEs or WYEs, for each mission Phase, A through F (as specified in Requirement CS-85 to Requirement CS-88) for Co-Is and Phases A through D for Collaborators.

NASA is committed to a culture of inclusion, diversity, equity, and accessibility (IDEA) where all employees feel welcome, valued, respected, and engaged. Inclusion is a NASA core value. To achieve mission success, NASA supports hiring, developing, and growing an inclusive and diverse workforce in a positive, safe, and equitable work environment where individuals can be authentic, have their voices heard, and be included as integral members of the team.

Building on this commitment, NASA also recognizes and supports the benefits of having inclusive and diverse scientific, engineering, and technology communities and fully expects that IDEA values will be reflected in the composition and culture of all study teams, as well as peer

review panels (science, engineering, and technology), science definition teams, and mission and instrument teams.

NASA expects that all mission projects will clearly define the principles by which team members can operate in an inclusive, equitable, and safe environment. These principles, as well as the processes in place for maintaining and improving the environment over the course of the mission, should be captured in a mission “Diversity and Inclusion Plan”.

In support of NASA's core value of Inclusion, see Requirement CS-109 in Appendix L.14.

The review of the merit of the Diversity and Inclusion Plan will be led by individuals with practical and/or research experience in IDEA topics and the application of IDEA principles to teams.

## **E.7 Plan for SEO**

**Requirement CS-27** If an SEO is proposed, this section shall define and describe plans the proposed activities (see Section 5.1.8 of the AO). The SEO shall be directly related to the mission (*i.e.*, analyze mission data, not enhance theory). The SEO shall be clearly separable from the Baseline Science Mission and Threshold Science Mission investigations. Additionally, a justification and a cost plan for SEO activities are required in Section K of this document.

## **F. MISSION IMPLEMENTATION**

### **F.1 General Requirements and Mission Traceability**

**Requirement CS-28** This section shall provide a description of the proposed spaceflight mission that will enable the science investigation.

In some areas (*e.g.*, instruments), the data requested may have already been presented in another section of the CSR (*e.g.*, the Science Implementation section). In such a case, a CSR may provide a reference to that section and need not repeat the data in this section.

**Requirement CS-29** The mission requirements that the science goals and objectives impose on the mission design elements, including mission design, instrument accommodation, spacecraft design, required launch vehicle capability, ground systems, communications approach, and mission operations plan, shall be provided in tabular form and supported by narrative discussion. Table B2 in the Program Library, or in Appendix B of the AO , provides an example of a tabular Mission Traceability Matrix, with examples of matrix elements. Specific information that describes how the science investigation imposes unique requirements on these mission design elements shall be included.

This Mission Traceability Matrix (MTM), along with the Science Traceability Matrix (STM), provides the reference points and tools needed to track overall mission requirements, provides systems engineers with fundamental requirements needed to design the mission, shows clearly



the effects of any descoping or losses of mission elements, and facilitates identification of any resulting degradation to the science.

## F.2 Mission Concept Descriptions

Requirement CS-30 Designs for all elements of the mission shall be described in sufficient detail to demonstrate that the mission concept meets all of the basic requirements for a space flight mission, including mission design, spacecraft design, supporting ground systems and mission operations, as provided in the evaluation factors defined in TMC Feasibility of the Proposed Mission Implementation in PART I above. Discussion of how the various mission elements meet the Mission Functional Requirements shall be included. At minimum, the following mission elements shall be addressed: mission design, flight system capability, mission operations, and any additional elements.

Requirement CS-31 Mission Design: This section shall address the following elements of the mission design to the extent that they are applicable to the proposed mission and that they are known. Any additional elements that are applicable to explaining the mission and demonstrating its feasibility shall also be addressed.

- Launch readiness date;
- Launch window, and launch date flexibility;
- Mission duration;
- Orbit type (Earth orbit, heliocentric, *etc.*) and orbit parameters (semi-major axis, eccentricity, inclination, node time of day, argument of perigee, altitude, allowable dispersions), and/or trajectory design and trajectory parameters for ballistic and low-thrust trajectories to permit independent validation, as applicable to the proposed investigation;
- Critical events, which includes LV separation telemetry;
- Telecomm link summary for all communication modes (based on requirements identified in Appendix L.18, Communications Design Data);
- Ground station(s) usage (*e.g.*, location(s), and transmitting and receiving communication parameters); and
- Space system's fault management approach and design.

Requirement CS-32 Launch Services and Launch Vehicle Compatibility: Compatibility with the proposed launch vehicle shall be demonstrated by providing in the appropriate CSR section the launch site; fairing size; spacecraft mass; launch mass margin; and mission orbit characteristics such as altitude (km – circular or apogee/perigee), inclination, C3, heliocentric and/or declination (DLA). Any known non-standard requirements such as additional fairing doors, cleanliness and purge requirements, planetary protection, *etc.*, shall be described. The packaged flight system in the proposed fairing, with critical clearance dimensions, and preliminary estimates of launch loads and structural margins shall be included.

APEX Phase A concept study teams are to continue to use the LV performance classes described in Section 5.9.2 of the AO and in the Program Library, with the same associated cost impacts. APEX Phase A concept study teams should work with John Calvert, Mission Manager, john.h.calvert@nasa.gov, for Launch Services Program support.

Requirement CS-33    Trajectory: For any mission traveling beyond Geostationary Earth Orbit (GEO) to achieve its science orbit, the following information shall be provided in the electronic submission as part of a Trajectory Supplement. This information is optional for missions that remain within Earth orbit at or below GEO. There is no requirement that this data also be included in the electronic CSR (PDF file). Any graphical references, tables, figures, *etc.* shall be presented in a minimum of 150 dots per inch (dpi).

- Checkout Duration: The minimum duration allocated after launch before the primary propulsion system will be commanded to provide required delta-v.
- Initial Mass Assumptions: Provide the initial mass used for generation of the trajectories including propellant loading assumptions.
- Event Basics: Provide the date/time of each trajectory event with a brief event description (*e.g.*, Launch, Gravity Assist, Fly-by, Rendezvous, Mid-Course Burn) and the appropriate data for the event (*e.g.*, flyby altitude, flyby angle, flyby/intercept velocity, delta-v magnitude). These data should be included for three different scenarios corresponding to the Open, Middle, and Closing of the proposed launch window.
- Event Body Ephemeris: Provide ephemeris data for all event bodies (fly-by planet, asteroid fly-by, comet rendezvous, *etc.*). Include the source of the ephemeris data and the epoch for the actual ephemeris point used for a particular event.

Any other trajectory specific information not called out above that would be relevant to reviewers attempting to validate the trajectory should also be included.

Requirement CS-34    Electric Propulsion (EP): For investigations using solar-electric propulsion, the following information shall be included in the electronic submission as part of a Trajectory Supplement:

- Power model for performance based on solar distance: Provide the functional relationship showing the performance of the solar arrays as a function of the spacecraft's distance from the Sun.
- EP Throttling Model: Provide the throttling model used to generate EP engine performance at any point during the trajectory and a brief explanation of the approach.
- Assumed Engine Duty Cycle: Provide the overall Duty Cycle for the EP engines and if applicable provide the duty cycle over each trajectory segment.
- Number of Engines: Provide the maximum number of engines on the spacecraft that could be operating simultaneously. In addition, provide the number of engines operating throughout each phase of the trajectory.

Any other trajectory specific information not called out above that would be relevant to reviewers attempting to validate the EP aspects of the trajectory and orbit, should also be included.

Requirement CS-35    Flight System Capabilities: This section shall address the following flight system capabilities to the extent that they are applicable to the proposed mission. Any additional elements that are applicable to explaining the mission and demonstrating its feasibility shall also be addressed. Note that the heritage of the components and subsystems are to be discussed in Appendix L.12.

- Spacecraft parameters:
  - (a) Figure of the complete spacecraft/instrument system, on the launch vehicle and in flight, with major components labeled and approximate overall dimensions.

- (b) Block diagram of the spacecraft subsystems and their components.
- Subsystem descriptions including structure, telecommunications, thermal, power, propulsion (if required), attitude determination and control, command and data handling, in-flight fault management, flight software, and ground software. (Note that the discussion of the telecommunications subsystem should be limited to specifications, design, and proposed component hardware – discussion of the link performance is addressed as part of Appendix L.18). Subsystem detail shall include the following information:
  - (a) Propulsion, including: (i) a list of all specific events of the proposed delta-v budget (including 3-sigma values for stochastic maneuvers); (ii) for each propulsion mode type (monoprop, biprop, dual-mode, solar electric, *etc.*), engines and thrust levels, specific impulse, (iii) propellant allocation (*e.g.*, impulse vs. attitude control system); and (iv) propellant margins, including nominal (to meet delta-v requirement) and additional (to meet mass growth).
  - (b) Command and data handling, including: (i) spacecraft housekeeping data rates for nominal and safing strategy; (ii) data storage unit size (Mbits); (iii) maximum storage record and playback rate.
  - (c) Power
    - Solar-powered mission:
      - (i) expected power requirement and margins for each mission phase, (ii) type of array structure (rigid, flexible, body mounted); (iii) solar array axes of rotation (vector projected in spacecraft coordinates); (iv) array size; (v) solar cell type and efficiency; (vi) expected power generation at beginning of life and end of life; (vii) worst case Sun incidence angle to solar panels for each mission phase; (viii) battery type and storage capacity; (ix) worst case battery depth of discharge (DOD); (x) spacecraft bus voltage.
  - (d) Attitude determination and control, including system pointing requirements and capabilities. Describe or define the following: (i) each spacecraft operational mode, including the sensors and actuators used, control method, and safing and/or contingency modes; (ii) attitude determination methodology and estimate of accuracy, including identifying whether ground post-processing is required to meet science needs; (iii) agility requirements for slews or scanning; (iv) appendage pointing requirements including articulation control methods and deployment accommodations; (v) sensor selection and performance including identifying mounting location and field-of-view (FOV); (vi) actuator selection and sizing including identifying mounting location(s); (vii) translational maneuver (delta-v) control and accuracy; (viii) momentum management approach and mitigation of impacts on navigation accuracy, if applicable; (ix) on-orbit calibrations, if required, including expected accuracy; and (x) attitude control requirements for the spacecraft pointing control, pointing knowledge (at the instrument interface), pointing stability or jitter.
  - (e) Thermal control, including: (i) temperature requirements including allowable temperature ranges; (ii) temperature control approach (*i.e.*, passive vs. active); (iii) cooling loads; and (iv) special thermal design considerations (*e.g.*, cryogenic instrument requirements).
  - (f) Structures, including: (i) requirements; (ii) governing load cases and margins; (iii) chosen materials; and (iv) their qualification testing.
  - (g) Flight software: (i) provide a description of the software architecture including the operating system, development language, and the major software modules to a sufficient depth to demonstrate how this software architecture supports the proposed mission

functions; (ii) provide the logical lines of code by Computer Software Configuration Item (CSCI) and the basis for these estimates; (iii) description of the functionality for each CSCI; (iv) code counts categorized as either New, Modified, Full Reuse, or Autogenerated; (v) development method (spiral, waterfall, agile, *etc.*); (vi) development approach for any major new algorithms to be incorporated in the flight software; (vii) the approach for interface management and plans for software verification.

Requirement CS-36    Additional Mission Elements: This section shall address any other major mission elements (*e.g.*, upper-stage, *etc.*) to the extent that they are applicable to the proposed mission. Any additional elements that are applicable to explaining the mission and demonstrating its feasibility shall also be discussed.

- Provide a block diagram and description of relevant subsystems; and
- Demonstrate that the proposed design can accomplish the mission within the allocated resources.

Requirement CS-37    Flight System Contingencies and Margins: This section shall summarize contingencies and margins of all key flight systems resources. It shall provide estimates of implementation performance and design margins with respect to the required performance. At a minimum, it shall include the following:

- Dry mass;
- Launch mass actually available to the proposed mission;
- Propellants;
- Power;
- CPU utilization;
- Data storage;
- Attitude control; and
- Any other driving mission element requirements derived from the Mission Functional Requirements.

See the table following Requirement B-41 of the AO for definitions of contingency and margin.

Requirement CS-38    Mission Operations: This section shall address, at a minimum, the following elements of mission operations and communication to the extent they are applicable to the proposed mission. Any additional elements that are applicable to explaining the mission operations and demonstrating their feasibility shall also be addressed.

- Description of ground systems and facilities, including supporting ground software at the Mission Operations Center (MOC) and the Science Operations Center (SOC) required for development and testing and operations;
- Telecommunications, Tracking, and Navigation including (i) downlink information and data volume for the PI-led investigation, including an estimate of the maximum raw data volume produced for GO investigations; (ii) uplink information; (iii) for all transmit and receive modes, provide mode timeline, data rate(s), durations, and compliance with maximum channel bandwidth; and (iv) ground network utilization plan including ground stations, downlink parameters (frequencies, periods, capacities, margins, *etc.*), and retransmission capability; and (v) for a Pointed Observatory, additional ground network utilization plan to enable GO investigations. For missions proposing the use of NASA network facilities, a Letter of

Commitment from the NASA network provider describing the network's ability to deliver the required capabilities and capacities and the cost for doing so must be included in Appendix L.1. Where the use of NASA's network services may not be within the capabilities and capacities described in the NASA's Mission Operations and Communications Services document, early discussions should be initiated with the POC named in that document;

- Description of approach for acquiring and returning critical event data, including clear identification of procurement and costing for supplemental resources (*e.g.*, mobile ground stations) if such are needed;
- Operations plan, including a quantitative discussion of nominal sequence planning and commanding showing the ability of the Mission Operations and Ground Data System to analyze the spacecraft and payload data and to generate the necessary sequences to enable the spacecraft to meet the planned mission timelines, team training, availability of spacecraft experts for operations, operations center development; and

Operational concept that includes the following. (i) Operational Scenarios with a description of each mission phase from launch through end of mission and an integrated description of the ground events and spacecraft/payload events for key mission phases, including proposed GO cadence if applicable. (ii) Timelines for each key mission phase; containing S/C, Payload, and ground events and processing and identifying margin for each phase if available. (iii) Data Flow Diagrams which clearly show the major operational facilities and key software components utilized for both the uplink and downlink processes, including interfaces for the GO program if applicable. (iv) A Phase E Organization diagram and Team Responsibilities clearly indicating the key manager for each of the project facilities in the data flow diagram, including how they will interface with the GO program if applicable. (v) An identification of the heritage of each project facility including: the software and hardware within that facility and the identification of the percentage of new, modified or no changes for each major software element. (vi) A plan for required maintenance and refresh of vendor supplied ground systems (hardware and software) during extended cruise operations. (vii) A plan for retention of adequate development and test resources, spacecraft and Ground Support Equipment (GSE) test beds, *etc.* during Phase E that addresses the impact of operations development and testing on routine and contingency mission operations. (viii) interface between the Flight Operations Team and the Conjunction Assessment Risk Analysis (CARA) team at NASA Goddard Space Flight Center for Earth-orbiting missions and the MARS (and Moon) Deepspace Collision Avoidance Process (MADCAP) team at the Jet Propulsion Laboratory for Moon and Mars missions.

Requirement CS-39 This section shall provide a clear statement of NASA SCA networks support requirements, preferably in tabular format. Show all mission phases (*e.g.*, launch and early orbital operations, cruise, flybys, orbit insertion, orbital operations, data return), the year in which support is needed, station(s) required, pass lengths in hours, number of passes each week, and the number of weeks for which this support is required. Separately identify support requirements for the PI-led investigation and the GO program, if applicable.

### F.3 Development Approach

Investigation teams shall describe how all development challenges, including those associated with new technology, will be addressed.

Requirement CS-40 This section shall describe the development plan. This description shall include the following items:

- The systems engineering approach shall be specifically discussed, including the definition, flow-down, tracking, control, and verification of design requirements; resource allocation and control; interface requirements; and hardware and software configuration control. This discussion of the systems engineering approach shall include roles and responsibilities and any unique aspects of the proposed mission that pose unusual system engineering challenges;
- Identification of instrument to spacecraft interfaces;
- Roles and responsibilities for the interface management process as specified in NPR 7123.1C;
- Identification of any special or unique implementation/interfaces for supplemental resources that may have been added for critical event coverage;
- Essential trade studies;
- Identification of the key Technical Performance Measures (TPMs)—as specified in NPR 7123.1C—and descriptions of how these margins and reserves are to be allocated, tracked, and monitored, with what tools and by whom, and who will have the authority to release the associated reserves and margins;
- Descriptions of when contracts are required, the acquisition strategy, including any incentive strategy;
- Management and closure of action items, hardware discrepancies, test anomalies, *etc.*; and
- Plan for handling special processes (*e.g.*, if radioactive sources are proposed, the approach to supporting the development, submittal, and approval of the necessary National Environmental Policy Act (NEPA) process and the Nuclear Launch Safety Approval (NLSA) process).

Requirement CS-41 This section shall describe the plan for mission assurance. Plans for using reliability tools, such as fault tree analysis, probabilistic risk assessments, and failure modes and effects analyses, shall be described. Other mission assurance activities such as fault tolerance, reliability (*e.g.*, use or non-use of redundancy, requirements for burn-in of parts, and requirements for total operating time without failure prior to flight) shall be described. Processes for identifying and tracking the correction of failures, both hardware and software, from the piece part to the system level shall be described.

Requirement CS-42 The CSR shall indicate any expected deviation(s) from the recommended requirements in the *Explorers and Heliophysics Projects Division (EHPD) Program Mission Assurance Requirements (MAR) – Class C* and in Appendix D of NPR 8705.4A for Category 2, Class C. Tailoring below the EHPD MAR shall not be proposed.

#### F.4 New Technologies/Advanced Engineering Developments

Requirement CS-43 This section shall describe any proposed new technologies and/or advanced engineering developments and the approaches that will be taken to reduce associated risks. Descriptions shall address, at a minimum, the following topics:

- Identification and justification of the TRL for each proposed system (Level 3 WBS payload developments and Level 3 WBS spacecraft elements) incorporating new technology and/or

advanced engineering development at the time the CSR is submitted (for TRL definitions, see NPR 7123.1C, *NASA Systems Engineering Processes and Requirements*, Appendix E, in the Program Library);

- Rationale for combining the TRL values of components and subsystems to derive each full system TRL as proposed, appropriately considering TRL states of integration (see NASA/SP-2016-6105 Rev. 2, *NASA Systems Engineering Handbook*);
- Rationale for the stated TRL value of an element that is an adaptation of an existing element of known TRL;
- The approach for maturing each of the proposed systems to a minimum of TRL 6 by PDR:
  - Demonstration (testing) in a relevant environment can be accomplished at the system level or at lower level(s);
  - If applicable, justify what demonstration(s) in a relevant environment at lower level(s) (subsystem and/or subsystem-to-subsystem) would be sufficient to meet system level TRL 6, considering: (i) where any new technology is to be inserted, (ii) the magnitude of engineering development to integrate elements, (iii) any inherent interdependencies between elements (*e.g.*, critical alignments), and/or (iv) the complexity of interfaces. See the Program Library for examples; and
  - Include discussion of simulations, prototyping, demonstration in a relevant environment, life testing, *etc.*, as appropriate;
- An estimate of the resources (staffing, cost, and schedule) required to complete the technology and/or advanced engineering development; and
- Approaches to fallbacks/alternatives that exist and are planned, a description of the cost, decision date(s) for fallbacks/alternatives, relevant development schedules, and performance liens they impose on the baseline design, and the decision milestones for their implementation.

If no new technologies or advanced engineering development is required, system TRL 6 or above at the time of CSR submission shall be clearly demonstrated.

#### F.5 Assembly, Integration, Test, and Verification

Requirement CS-44 An illustration and discussion of the time-phased flow of the Integration and Test (I&T) Plan shall be presented. It shall include the key facilities, testbeds, and team members involved in the I&T Plan.

Requirement CS-45 The project's assembly, integration, test, and verification (AIT&V) approach shall be described in this section. Flow diagrams, narrative text, and/or other relevant data may be used to convey this information. Elements of the approach that pose special challenges for the project (*e.g.*, mission critical performance or functional requirements that cannot be tested on the ground, multiple-build units, special facilities that may be required for testing, large scale simulation tools that are required to be developed and how they will be validated, critical path items, *etc.*) shall be included. The AIT&V description shall demonstrate the credibility of the overall AIT&V approach, as reflected by consistency between the described plans and the schedule, cost, and other resources needed to carry them out. The testing and verification of the space system's fault management approach and implementation shall be discussed.

## F.6 Schedule

**Requirement CS-46** A project schedule foldout(s) covering all phases of the investigation shall be provided. The schedule shall be provided to at least WBS level 3 for the spacecraft elements (one level below the spacecraft level) and Level 4 for payload elements (one level below each instrument), where the data are available, except where greater detail is necessary to identify critical paths. Significant TRL or engineering development activities and events must be covered. Schedule foldout(s) will not be counted against the page limits. The schedule format shall indicate the month and year of each milestone, have a corresponding table of dates, and follow standard NASA WBS elements for task descriptions as prescribed in NPR 7120.5F. The schedule foldout(s) and accompanying narrative shall address proposed major milestones, including, at a minimum, the following items:

- Spacecraft development, integration and test, and major review dates;
- Activities for advancement to TRL 6, and other key engineering development activities;
- Instrument development and major review dates including instrument-to-spacecraft/host integration and test;
- Ground systems development and major review dates (*e.g.*, mission operations and data analysis development schedule);
- Major deliverables (*e.g.*, Interface Control Documents (ICDs), simulators, engineering modules, flight modules, *etc.*);
- Launch vehicle integration and launch readiness;
- Compliance with National Environmental Policy Act (NEPA) and Nuclear Launch Safety Approval processes, if appropriate;
- Long-lead item specifications, development paths, and their impacts to schedule;
- Development schedule for Student Collaborations (SCs); Science Enhancement Options (SEOs); Citizen Science (CS), if any;
- Schedule critical path identification, including any significant secondary critical paths; and
- Funded schedule reserve, with indications of appropriate reserves associated with major milestones and deliverables, including allocated critical path reserves; and
- Schedule for Diversity and Inclusion Plan development and implementation.

**Requirement CS-47** The electronic submission shall also contain an electronic version of the schedule in a Microsoft Project format. Although the project schedule foldout(s) in Requirement CS-46 does not need to have been generated in Microsoft Project, the project schedule provided [in the electronic submission](#) shall address the items specified in Requirement CS-46 at a level of detail commensurate with that of the graphical foldout. The Microsoft Project schedule is not intended to be a fully Integrated Master Schedule for the project, but rather, it is to be a representation of the summarized schedule foldout that provides quantified data set that will facilitate understanding of the proposed flow of development activities, timelines, milestones, schedule reserves, and risk. The level of linkage detail must be complete enough to substantiate the assignment of the primary critical path and any significant secondary critical path(s) in the graphical foldout(s). Task links are also needed to identify points of assembly, integration, and testing in the schedule and links to major milestones. A Phase B schedule consistent with the plans detailed in Section I shall be included in the file.



## G. MANAGEMENT

Requirement CS-48 This section shall describe the management approach, including essential management functions and the overall integration of these functions:

- The organizational structure, including:
  - a) An organization chart that clearly indicates how the investigation team is structured;
  - b) The internal operations and lines of authority with delegations, together with internal interfaces;
  - c) Relationships with NASA, major subcontractors, and associated investigators; and
  - d) The names of the primary team members, their organizations, and their reporting relationships in the program; and
- The commitments and the roles and responsibilities of all institutional team members, including team members responsible for SC and CS (as applicable).

Requirement CS-49 This section shall demonstrate how the proposer's plans, decision-making processes, tools (including performance measurement and reporting), and organization will be applied to manage and control the project during development and operation. The decision-making processes that the team will use shall be described, focusing particularly on the roles of the PI, DPI if one is proposed, PM, PSE, and the balance of the Key Management Team in those processes. In particular, the management processes as they apply to the relationships among organizations and key personnel shall be described, including systems engineering and integration; requirements development; configuration management; schedule management; team member coordination and communication; progress reporting (both internal and to NASA); performance measurement; and resource management. This discussion shall include all phases of the mission, including preliminary analysis, technical definition, design and development, and operations phases, as well as products and results expected from each phase. Include a clear description of the methods and frequency of planned communication within the project team.

Requirement CS-50 This section shall summarize the relevant institutional experience and refer to supporting detail included in Section L.2, Relevant Experience and Past Performance. If experience for a partner organization is not equivalent to, or better than, the requirements for the proposed mission, explain how confidence can be gained that the mission can be accomplished within cost and schedule constraints.

Requirement CS-51 Each key position, including its roles and responsibilities, how each key position fits into the organization, and the basic qualifications required for each key position, shall be described. A discussion of the unique or proprietary capabilities that each partner organization brings to the team, along with a description of the availability of personnel at each partner organization to meet staffing needs, shall be included. The contractual and financial relationships between team partners shall be described.

Requirement CS-52 This section shall name all of the team members who will occupy the key project management positions identified in Requirement CS-51. It shall, in addition:

- (i) Describe the previous work experience of each of these key individuals, including the outcomes and complexity of the work they did, and it shall explain the relevance of these experiences to the responsibilities of the key project management positions they will occupy;

- (ii) Provide any program/project management certifications held by or planned to be obtained by the PM; and
- (iii) Address the role(s), responsibilities, commitments by phase, and percentage of time devoted to the mission for the PI, DPI if one is named, PM, PSE, and all other named key management individuals, and shall provide reference points of contact, including address and phone number, for each of these individuals.

Requirement CS-53 This section shall describe plans for risk management, both in the overall mission design and in the individual systems and subsystems. NASA's required risk management procedures are provided in NPR 8000.4C, *Agency Risk Management Procedural Requirements*, available in the Program Library. The *Explorers & Heliophysics Projects Division (EHPD) Mission Assurance Requirements (MAR) Mission Risk Classification – Class C* document, available in the Program Library, will also apply. Note that the MAR requires a draft Mission Assurance Implementation Plan (MAIP) and Compliance Matrix to be submitted with the CSR (see Section L.22 of this document). Plans for using standard risk management tools, including probability and impact charts, risk lists, mitigation plans and triggers shall be described. The role(s) in the risk management process of each of the key management personnel shall be discussed. Provide quantitative risk assessments, where the probability and impact of occurrence are independently and numerically specified prior to mitigation; specification of probability and impact after mitigation is encouraged but not required. Where appropriate, an impact may be specified in terms of any resource that is quantified in the CSR. Furthermore, individual quantitative risk assessments may address multiple resources, as well as temporal increments (e.g., mitigation followed by post-mitigation). In order to determine the cumulative effect of risks on resources, each impact must be paired with a probability. The cumulative effect of the products of probabilities and impacts must not reduce the resource below that necessary to achieve baseline science. In the case of cost, the products of pre-mitigation probabilities and impacts shall be included as encumbered cost reserves or explicitly identified in the basis of estimate, including cost validations.

Requirement CS-54 This section shall include a discussion of the management approaches for controlling cost growth.

Requirement CS-55 A summary of reserves in cost and schedule shall be identified by mission phase, project element, and year, and the rationale for each shall be discussed. The specific means by which integrated costs, schedule, and technical performance will be tracked and managed must be defined. Specific reserves and the timing of their application must be described. Management of the reserves and margins, including who in the management organization manages the reserves and when and how the reserves are released, must be discussed. This must include the strategy for maintaining reserves as a function of cost-to-completion. All funded schedule margins shall be identified. The relationship between the use of such reserves, margins, potential descope options, and their effect on cost, schedule, and performance must be fully discussed. When considering potential descope options, consider the investigation as a total system including instrument(s), spacecraft, ground system, launch services, and operations.

Requirement CS-56 This section shall clearly delineate the Government-furnished property, services, facilities, *etc.* required to accomplish all phases of the mission.

Requirement CS-57 This section shall list the major project reviews expected to be conducted during the project's life cycle consistent with NPR 7120.5F and the approximate time frame in the Project Schedule for each review.

NASA NPR 7120.5F establishes the requirements by which NASA formulates and implements space flight programs and projects. This document emphasizes program and project management based on life cycles, Key Decision Points (KDPs), and evolving products during each life-cycle phase.

Tailoring to NASA requirements described in NPR 7120.5F may be proposed by missions at any risk classification. Proposers must identify any tailorable requirements that are proposed to be adjusted, provide a rationale for each adjustment, and describe the cost, schedule, and/or other benefits that would be realized should one or more of the adjustments be accepted by NASA. Note that these adjustments reflect potential modifications to the baseline investigation, to be addressed after down-selection.

The panel evaluating the third evaluation criterion, TMC Feasibility of the Proposed Investigation Implementation, will provide comments to the Selection Official on the proposed tailoring of the requirements and their justifications. These comments will not be considered for the TMC Feasibility of the Proposed Investigation Implementation risk rating but may be considered in the selection decision.

Requirement CS-58 CSRs shall identify any tailorable NASA requirements described in NPR7120.5F that are proposed to be adjusted, include the rationale for the adjustment, and describe the cost, schedule, and/or other benefits that would be realized should one or more of the adjustments be accepted by NASA.

Requirement CS-59 This section shall clearly describe the approach to reporting progress to the Government, and indicate the progress reviews the Government is invited to attend to provide independent oversight. The process, including the individual or organization responsible, for reporting integrated cost, schedule, and technical performance must be discussed. A description of the information to be presented must be included.

Requirement CS-60 This section shall describe plans to retire risk due to uncertainty associated with contributions by the end of Phase A. It shall address:

- Commitments for contributions from implementing organizations and/or other funding agencies. Letters of commitment from all organizations involved in a contribution, particularly including the implementing organization (*e.g.*, laboratory or institute) and if external funding is required the funding agency (*e.g.*, national space agency), shall be provided as an appendix (see Section L.1, Requirement CS-92 and Requirement CS-93);
- Mitigation plans, where possible, for the failure of funding and/or contributions to be provided when that funding and/or contributions are outside the control of the PI. Mitigation may include, but is certainly not limited to, descoping the contributed items and holding reserves to develop the contribution directly. Note that reserves held for this purpose should be weighted by likelihood and are considered encumbered. When no mitigation is possible,

- this must be explicitly acknowledged, and the stability and reliability of proposed partners, as well as the appropriateness of any proposed contribution, should be addressed; and
- Acknowledgement of the complexities and risks involved with contributions, and plans to handle those complexities or risks. This includes the schedule risk for implementing technical assistance agreements and international agreements. An adequate and realistic schedule must be allocated for having international agreements executed. NASA will not begin working on any international agreements until after the continuation decision is made.

## **H. OTHER FACTORS, INCLUDING SCs and CSs**

**Requirement CS-61** If a Student Collaboration is proposed, this section shall describe a detailed plan. This plan shall include:

- A summary description of the planned SC;
- A development schedule for the SC, including decision points for determining readiness for flight;
- A demonstration of how the SC will be incorporated into the mission investigation on a non-impact basis;
- A demonstration of how the SC will be clearly separable from the rest of the mission investigation;
- A plan for recruiting student participants, including a description of recruitment and retention policies likely to reach individuals from groups under-represented in STEM;
- A plan for the mentoring and oversight of students to maximize the opportunity for teaching, learning, and success in contributing to the mission;
- An appropriate plan for evaluation; and
- Identification of the cost of the SC separately from the investigation.

**Requirement CS-62** If a CSR contains a SC, the CSR shall demonstrate that the proposed SC is clearly separable from the proposed Baseline and Threshold Science Missions; will not increase the mission development risk; and will not impact the science investigation in the event that the SC is not funded, fails during flight operations, or encounters technical, schedule, or cost problems during development.

**Requirement CS-63** If a CSR contains a SC, the CSR shall identify the funding set aside for the SC, and any contributions to the SC. This funding may be outside the PI-Managed Mission Cost up to the Student Collaboration incentive, and any SC costs beyond the Student Collaboration incentive, unless contributed, shall be within the PI-Managed Mission Cost.

**Requirement CS-64** If a CSR contains CS, this section shall describe a CS plan. This plan shall describe the interaction between the citizen scientists and the project, and shall address aspects that include but are not limited to:

- definition and ensurance of a meaningful, positive participant experience;
- engagement and utilization of enthusiast communities and platforms that the activity would engage and utilize;
- development of new platforms and/or communities, including
- sufficient discussion to demonstrate the necessity or benefit of their development,

- the capability for the investigation to develop them, and
- a backup to existing platforms and/or communities, including discussion of project degradation, if new developments are not approved;
- beta testing with citizen scientists before full public access and engagement;
- ensurance of broad participation appropriate to the nature of the project, including the collection and analysis of user data (and other data, as appropriate); and
- a link to NASA’s citizen science website ([science.nasa.gov/citizenscience](https://science.nasa.gov/citizenscience)) on any citizen science project website.

**Requirement CS-65** CSRs that include Citizen Science shall include a Citizen Science sunset plan within the Citizen Science Plan. This plan shall address both communications with all contributing citizen science volunteers and final modifications to and permanent archiving of activity websites.

**Requirement CS-66** CSRs that contain Citizen Science shall designate the Co-Investigator(s) that are responsible for coordinating and managing the Citizen Science and its participants. CSRs shall not list individual citizen scientists that are not otherwise members of the Science Team.

**Requirement CS-67** If a CSR contains CS, the CSR shall demonstrate that the proposed CS is clearly separable from the proposed Baseline and Threshold Science Missions; will not increase the mission development risk; and will not impact the science investigation in the event that the CS is not funded, fails during flight operations, or encounters technical, schedule, or cost problems during development.

**Requirement CS-68** If a CSR contains CS, the CSR shall identify the funding set aside for the CS, and any contributions to the CS. This funding may be outside the PI-Managed Mission Cost up to the CS incentive, and any CS costs beyond the CS incentive, unless contributed, shall be within the PI-Managed Mission Cost.

## **I. PRELIMINARY DESIGN AND TECHNOLOGY COMPLETION (PHASE B) PLAN**

Once entering Phase B, APEX projects will be subject to the same requirements as all other NASA missions. Note that the CSR only satisfies some of the KDP-B deliverable requirements, and that the balance will have to be developed early in Phase B (consistent with Section 2.2.7.1 in NPR 7120.5F: “In a two-step AO process, projects are down-selected following evaluation of concept study reports and the down-selection serves as KDP B. Following this selection, the process becomes conventional with the exception that products normally required at KDP B that require Mission Directorate input or approval will be finished as early in Phase B as feasible.”).

**Requirement CS-69** This section shall address plans and products for the Preliminary Design and Technology Completion Phase (Phase B). It shall identify the key mission tradeoffs to be performed and options to be investigated during Phase B that could lead to reductions in risk of implementation, including those issues, technologies, and decisions points critical to mission success. This section shall also describe and provide the rationale for any anticipated long-lead acquisitions.

Requirement CS-70 The Phase B Plan shall include a detailed schedule, and shall define the products to be delivered and the schedule for their delivery. The schedule shall include the PDR and delivery dates of the following required products:

- A detailed descope plan including the criteria, impact and savings of descope options;
- A complete set of baseline Level 1 requirements including mission success criteria; and
- The baseline project plan.

Requirement CS-71 If more than one contractual arrangement is needed, a separate Statement of Work (SOW) and budget breakout shall be provided for each organization. Subsequent phases will be added to the contract after each phase has been approved through the confirmation review process.

## **J. COST PROPOSAL**

All cost tables referenced in this section are provided as templates in the Program Library.

Requirement CS-72 A WBS as defined in NPR 7120.5F and NASA/SP-20210023927, NASA Work Breakdown Structure (WBS) Handbook, available in the Program Library, shall be provided and used to describe how all project costs are accounted in the cost proposal.

Requirement CS-73 This section shall include the estimated cost of the proposed investigation. The estimated cost shall encompass all proposed activities, including all applicable mission phases, mission unique or special launch services (*e.g.*, load isolation systems, unique mechanical/electrical interfaces, payload processing facilities, commodities, post-encapsulation access requirements, supplemental propulsion systems, deployable telemetry tracking assets, and GN2 purge), flight systems, interface between the Flight Operations Team and the CARA or MADCAP team, ground systems, ground network fees, contributions, any other AO-specific activities (*e.g.*, SC), and all cost reserves. Cost for ground network fees, data archive, and other mission-unique elements shall be clearly described. These costs shall be consistent with the policies and requirements in Sections 4 and 5 of the AO.

Requirement CS-74 This section shall provide a Basis of Estimate (BOE) clearly traceable to the WBS of Tables B3a and B3b, including a description of the methodologies and assumptions used to develop the proposed cost estimate. The cost estimating methodology discussion in this section shall provide an overview of the cost estimate development process. Additional cost estimates or other validation efforts shall be described, the results presented, and any significant discrepancies discussed. A description of cost reserves that provides insight into the adequacy and robustness of the proposed unencumbered cost reserve level(s) shall be provided. The rationale for the proposed cost reserve levels shall be presented. The following is a non-exhaustive list of examples of useful BOE data for different cost estimating methodologies.

- Example for system and subsystem estimates based on analogy. Include the original heritage cost and rationale for any adjustments used to obtain the current proposed element costs.
- Example for system and subsystem estimates based on a parametric model. Provide the name and version of the model, general heritage assumptions and other key inputs used that can help explain the cost estimate.

- Example for bottom-up system and subsystem estimates, provide information on what portion of the WBS element is labor vs material. For the labor, provide a breakout of FTEs and/or WYEs by year with average labor rates. For material provide a summary list of the significant hardware quotes used in the estimate, the date of the quote, and the importance of the quoted hardware to mission success.

Requirement CS-75 This section shall include a discussion of sources of estimate error and uncertainty in the proposed cost.

Requirement CS-76 This section shall include a discussion of cost risks and mitigation strategies.

Requirement CS-77 This section shall provide two foldout cost tables, using the template of Cost Table Templates 3a and 3b. The tables shall identify the proposed cost required in each mission phase and in each NASA fiscal year; the costs shall be in Real Year dollars (RY\$) in Table 3a and in FY 2023 dollars in Table 3b. The top portion of the tables shall contain cost data relevant to the PI-Managed Mission Cost. The lower portion shall contain cost data for contributions and enhanced mission costs. The rows in the tables shall be the NASA standard WBS elements as defined in NPR 7120.5F and NASA/SP-20210023927. The costs for most elements shall be provided at least to WBS Level 3. It is requested that instruments be shown to WBS Level 4 where the data is available. The costs of individual instruments and any unique flight system elements such as coordinating science ground stations, or nonstandard facilities and non-standard elements, shall be explicitly shown. The columns in the tables shall be grouped and subtotaled by mission phase and shall be labeled with the appropriate Fiscal Years. Years that span more than one mission phase shall be split into two columns by mission phase. The tables include totals by WBS and by phase and life cycle in both RY\$ and Fiscal Year 2023 dollars (FY23\$). Investigation teams shall use their own forward pricing rates to translate between RY\$ and FY23\$. For organizations that are without approved forward pricing rates, investigation teams may use the NASA inflation/deflation indices available in the Program Library to translate between RY\$ and FY23\$.

Requirement CS-78 The description of the BOE shall include a discussion of heritage and commonality with other programs. Quantify and explain any cost savings that result from heritage.

Requirement CS-79 Provide a table with the new obligation authority (NOA) required in RY\$ by fiscal year using the format of Cost Table Template 6. If the mission is selected for flight, SMD will use this information to prepare its budget request.

Requirement CS-80 For Phase B only, a time-phased cost breakdown for each WBS element, using the template of Cost Table Template 2, shall be completed. Use only the line items shown in Cost Table Template 2 that are relevant for each phase of the project. The purpose of this set of tables is to provide detailed insight into how the project allocates funding during each phase of work.

Requirement CS-81 The CSR shall identify each reserve amount to the lowest level consistent with the proposed reserve management strategy. For example, if each subsystem manager will have spending authority over a reserve for the subsystem, each such amount shall be identified separately. If more convenient, the reserve details may be shown in a separate table, with totals reported using each of Cost Table Templates 3a and 3b. Show costs (NASA SMD and contributed) associated with each Co-I and collaborator using Cost Table Templates 4a and 4b respectively, on one page each; all Co-Is and collaborators shall be identified in the applicable table.

Requirement CS-82 All contributions and direct/indirect costs associated with the work performed at NASA Centers shall be fully costed and accounted for in the CSR, and summarized in one page using the template provided in Cost Table Template 5. NASA Center costs shall include Civil Servant services, as well as the cost for the use of Government facilities and equipment on a full-cost accounting basis. The purpose of this data is twofold: 1) to determine those costs that are included in the NASA SMD cost but are not funded out of the Explorers program, and 2) to determine Civil Servant contributions that are not included in the NASA SMD cost. Teams should work with their respective NASA Centers to develop estimates for these costs. Contributions by NASA Centers should be documented by a Letter of Commitment, provided as an appendix (see Section L.1, Requirement CS-92 and Requirement CS-93).

Definitions for cost element terms shown in the cost tables are provided in Appendix C.2 of the AO.

Requirement CS-83 The inflation index provided in the tables found in the Program Library shall be used to calculate all real-year dollar amounts, if an industry forward pricing rate is not available. If something other than the provided inflation index is used, the rates used must be documented.

Requirement CS-84 All costs shall include all burdens and profit/fee in real-year dollars by fiscal year, assuming the inflation rates used by NASA in the Program Library, or specifically documented industry forward pricing rates.

Requirement CS-85 This section shall provide a detailed cost proposal for performing Phase B. The cost proposal should correlate with the plans set forth in the concept study. This cost proposal shall include the following elements:

- Contract Pricing Proposal. Complete cost and pricing data for Phase B shall be included with the CSR as an appendix (see Section L.4 and Requirement CS-96).
- Work Breakdown Structure. A WBS shall be provided for Phase B. The structure of the WBS should be consistent with the plans set forth in the Science Implementation, Mission Implementation, and Management sections of the concept study and the Statement of Work provided as an appendix to the concept study. The WBS shall be described to the subsystem level (*e.g.*, Attitude Control System, Propulsion, Structure and Mechanisms) for the spacecraft, to at least the instrument level for simple instruments, and to the major component level for more complicated instruments. All other WBS elements shall be at least to the major task level (*e.g.*, Project Management, Systems Engineering, GSE).



- Workforce Staffing Plan. A workforce staffing plan that is consistent with the WBS shall be provided. This plan shall include all team member organizations and must cover all management, technical (scientific and engineering), and support staff. The workforce staffing plan shall be phased by month. Time commitments for the PI, DPI if one is named, PM, PSE, Co-Is, and other key personnel must be clearly shown.
- Proposal Pricing Technique. The process and techniques used to develop the cost proposal for Phase B shall be described. For portions of the cost proposal developed with a grass-roots methodology, the bases from which the estimates were derived and details on how the estimates were extrapolated from the bases shall be provided. For portions of the cost proposal derived from vendor quotes/historical actuals/catalogue prices/*etc.*, information sufficient to understand the fidelity of the values shall be provided. For portions of cost the proposal derived from analogies, the value of and the methodology for extrapolating the analogy shall be described. For portions of the cost proposal derived parametrically, the cost-estimating model(s) and techniques used in the cost estimate for Phase B shall be described. The heritage of the models and/or techniques applied to this estimate, including any differences between missions contained in the model's database and key attributes of the proposed mission shall be described. Assumptions used as the basis for the cost for Phase B shall be included, and those that are critical to cost sensitivity in the investigation shall be identified. If any "discounts" were assumed in the cost estimates for business practice initiatives or streamlined technical approaches, a description of how these have been incorporated in the cost estimate and will be managed by the investigation team shall be provided.
- Phase B Time-Phased Cost Summary. A summary of the total costs for Phase B consistent with the table created for Requirement CS-80 (Cost Table Template 2) shall be provided. The cost summary for Phase B shall be developed consistent with the WBS and include all costs to NASA SMD along with all contributed costs. The cost summary for Phase B shall be phased by month.
- Elements of Cost Breakdown. Cost or pricing data as defined in FAR 15.401 and supporting evidence stating the basis for the estimated costs by the WBS levels used in the table created for Requirement CS-80 (Cost Table Template 2) shall be provided. This information is in addition to that provided in Requirement CS-77 through Requirement CS-81 (Cost Table Templates 1 through 5). The cost proposal shall include, but is not limited to, the following cost elements:
  - (a) Direct Labor. (i) The basis of labor-hour estimates for each of the labor classifications; (ii) the number of productive work-hours per month; (iii) a schedule of the direct labor rates used in the proposal, with a discussion of the basis for developing the proposed direct labor rates for the team member organizations involved; the forward-pricing method (including midpoint, escalation factors, anticipated impact of future union contracts, *etc.*); and elements included in the rates, such as overtime, shift differential, incentives, and allowances; (iv) if available, evidence of Government approval of direct labor rates for proposal purposes for each labor classification for the proposed performance period; and (v) if Civil Servant labor is to be used in support of the Phase B study, but is not to be charged directly to the investigation, this labor shall be considered as a contribution by a domestic partner, subject to the same restrictions as other contributions by domestic or foreign partners, and a discussion of the source of funding for the Civil Servant contributions shall be provided.

- (b) Direct Material. A summary of material and parts costs for each element of the WBS shall be provided.
- (c) Subcontracts. Each effort (task, item, *etc.*, by WBS element) to be subcontracted, and list the selected or potential subcontractors, locations, amount budgeted/proposed, and types of contracts shall be identified. Explain the adjustments, if any, and the indirect rates (or burdens) applied to the subcontractors' proposed or anticipated amounts. Describe fully the cost analysis or price analysis and the negotiations conducted regarding the proposed subcontracts.
- (d) Other Direct Costs. (i) A summary of travel and relocation costs, including the number of trips, their durations, and their purposes; (ii) a summary of all unique computer related costs; (iii) specific task areas of problems that require consultant services, including the quoted daily rate, the estimated number of days, associated costs (*e.g.*, travel) if any, and a statement of whether the consultant has been compensated at the quoted rate for similar services performed with Government contracts; and (iv) any other direct costs included in the proposal for Phase B, provided in a manner similar to that described above.
- (e) Indirect Costs. (i) all indirect expense rates for the team member organizations (in the context of the AO, indirect expense rates include labor overhead, material overhead, general and administrative [G&A] expenses, and any other cost proposed as an allocation to the proposed direct costs); (ii) a schedule of off-site burden rates, including a copy of the company policy regarding off-site vs. on-site effort, if applicable; (iii) evidence of Government approval of any/all projected indirect rates for the proposed period of performance, including the status of rate negotiations with the cognizant Government agency, and a comparative listing of approved bidding rates and negotiated actual rates for the past five fiscal years; and (iv) fee arrangements for the major team partners.

Requirement CS-86 This section shall provide a cost estimate for performing the Final Design and Fabrication/System Assembly, Integration and Test, and Launch (Phase C/D) portion of the mission. The Phase C/D cost estimates shall correlate with the plans set forth in the concept study. In completing this section, the following guidelines will apply:

- Work Breakdown Structure. A WBS shall be included for Phase C/D. The WBS shall be described to the subsystem level (*e.g.*, Attitude Control System, Propulsion System, Structure and Mechanisms) for the spacecraft and to the instrument level for the payload. All other elements of the WBS should be to the major task level (Project Management, Systems Engineering, GSE, *etc.*).
- Cost Estimating Techniques. The process and techniques used to develop the Phase C/D cost estimate shall be described and a description of the cost estimating model(s) and techniques used in the Phase C/D cost estimate shall be provided. The heritage of the models applied to this estimate including any differences between missions contained in the model's database and key attributes of the proposed mission shall be discussed. Include the assumptions used as the basis for the Phase C/D cost and identify those that are critical to the cost sensitivity in the investigation. Identify any "discounts" assumed in the cost estimates for business practice initiatives or streamlined technical approaches and the basis for these discounts. Describe how these have been incorporated in the cost estimate and will be managed by the investigation team.
- Workforce Staffing Plan. A workforce-staffing plan (including Civil Servants) that is

consistent with the WBS shall be provided. This workforce-staffing plan shall include all team member organizations and should cover all management, manufacturing, technical (scientific and engineering), and support staff. The workforce-staffing plan shall be phased by fiscal year. Time commitments for the PI, DPI if one is named, PM, PSE, Co-Is, and other key personnel shall be clearly shown.

- Phase C/D Time-Phased Cost Summary. A summary of the total Phase C/D costs consistent with the WBS in Requirement CS-80 (Cost Table Template 2) shall be provided. The Phase C/D cost summary shall be consistent with the WBS and shall include all costs to NASA, along with all contributed costs. The Phase C/D cost summary shall be phased by fiscal year. Phase C/D extends 30 days beyond launch so be sure to account for all costs for this period, including tracking support and mission operations.

Requirement CS-87 This section shall provide a cost estimate for performing the Operations and Sustainment Phase (Phase E) of the mission. The Phase E cost estimates shall correlate with the plans set forth in the concept study. In completing this section, the following guidelines will apply:

- Work Breakdown Structure. A WBS must be included for the Mission Operations and Data Analysis Phase of the mission. The WBS should be consistent with the plans set forth in the concept study and the Statement of Work that is provided as an appendix.
- Cost Estimating Technique. Describe the process and techniques used to develop the Phase E cost estimate. For portions of the cost proposal developed using a grass-roots methodology, provide the bases from which the estimates were derived and details on how the estimates were extrapolated from the bases. For portions of the cost proposal derived from vendor quotes/historical actuals/catalogue prices/*etc.* include sufficient information to understand the fidelity of the values. For portions of cost in the CSR derived from analogies, describe the value of and the methodology for extrapolating the analogy. For portions of the cost proposal derived parametrically, provide a description of the cost-estimating model(s) and techniques used in the Phase E cost estimate. Discuss the heritage of the models applied to this estimate including any differences between missions contained in the model's database and key attributes of the proposed mission. Include the assumptions used as the basis for the Phase E cost and identify those which are critical to cost sensitivity in the investigation. If any "discounts" were assumed in the cost estimates for business practice initiatives or streamlined technical approaches, describe how these have been incorporated in the cost estimate and will be managed by the investigation team.
- Workforce Staffing Plan. Provide a workforce staffing plan (including Civil Servants) which is consistent with the WBS. This workforce staffing plan must include all team member organizations and must cover all management, manufacturing, technical (scientific and engineering), and support staff. The workforce staffing plan must be phased by fiscal year. Time commitments for the PI, DPI if one is named, Co-Is, PM, PSE, and other key personnel must be clearly shown.
- Phase E Time-Phased Cost Summary. Provide a summary of the total Phase E costs consistent with the WBS in Requirement CS-80 (Cost Table Template 2). The Phase E cost summary should be developed consistent with the WBS and must include all costs to NASA SMD, along with all contributed costs. The Phase E cost summary must be phased by fiscal year.

Requirement CS-88 This section shall provide a cost estimate for performing the Closeout Phase (Phase F) of the mission. The Phase F cost estimates should correlate with the plans set forth in the Science Investigation, Science Implementation, Mission Implementation, and Management sections. In completing this section, the following guidelines will apply:

- Work Breakdown Structure. A WBS must be included for the Closeout of the mission. The WBS should be consistent with the plans set forth in the Science Implementation, Mission Implementation, and Management sections and the Statement of Work that is provided as an appendix.
- Cost Estimating Technique. Describe the process and techniques used to develop the Phase F cost estimate. For portions of the cost proposal developed using a grass-roots methodology, provide the bases from which the estimates were derived and details on how the estimates were extrapolated from the bases. For portions of the cost proposal derived from vendor quotes/historical actuals/catalogue prices/*etc.* include sufficient information to understand the fidelity of the values. For portions of cost the proposal derived from analogies, describe the value of and the methodology for extrapolating the analogy. For portions of the cost proposal derived parametrically, provide a description of the cost-estimating model(s) and techniques used in the Phase F cost estimate. Discuss the heritage of the models applied to this estimate including any differences between missions contained in the model's database and key attributes of the proposed mission. Include the assumptions used as the basis for the Phase F cost and identify those which are critical to cost sensitivity in the investigation. If any "discounts" were assumed in the cost estimates for business practice initiatives or streamlined technical approaches, describe how these have been incorporated in the cost estimate and will be managed by the investigation team.
- Workforce Staffing Plan. Provide a workforce staffing plan (including Civil Servants) which is consistent with the Work Breakdown Structure. This workforce staffing plan must include all team member organizations and must cover all management, manufacturing, technical (scientific and engineering), and support staff. The workforce staffing plan must be phased by fiscal year. Time commitments for the PI, DPI if one is proposed, Co-Is, PM, PSE, and other key personnel must be clearly shown.
- Phase F Time-Phased Cost Summary. Provide a summary of the total Phase F costs consistent with Requirement CS-80 (Cost Table Template 2). The Phase F cost summary should be developed consistent with the Work Breakdown Structure and must include all costs to NASA SMD, along with all contributed costs. The Phase F cost summary must be phased by fiscal year.

Requirement CS-89 This section shall summarize the estimated costs to be incurred in Phases A through F, including: Concept and Technology Development (Phase A), Preliminary Design and Technology Completion (Phase B); Final Design and Fabrication (Phase C); System Assembly, Integration and Test, and Launch, extending through in-orbit checkout, usually launch plus 30 days (Phase D); Operations and Sustainment (Phase E); Closeout (Phase F); LV, upper stages, or launch services; ground system costs beyond what is provided by the AO; and cost of activities associated with social or educational benefits (if not incorporated in any of Phases A through F). The Cost Table Template 1 shall be used to summarize these costs. The total mission cost estimate shall be consistent with the Work Breakdown Structure. Detailed plans for any aspects of the mission not discussed elsewhere in the CSR shall be discussed here. The funding profile shall be optimized for the mission. Contributions not included in the NASA SMD cost shall be clearly identified as separate line items.

Immediately following the continuation decision (*i.e.*, down-selection), the contractor will be requested to submit a formal cost proposal based upon the Federal Acquisition Regulation (FAR) Part 15. The instruction and format for submission of this formal cost proposal are found in FAR Part 15.403-5 and Table 15.2. The definitive contract will include an option provision for Phases B, C/D, E, and F with a not-to-exceed amount for each phase.

**Requirement CS-90** The cost elements proposed in the formal proposal for contract award shall be traceable to the cost proposal provided in the CSR. Any changes in cost from the CSR shall be described in detail.

## **K. JUSTIFICATION AND COST PROPOSAL FOR ANY SCIENCE ENHANCEMENT OPTION**

SEO activities, discussed in AO Section 5.1.8, include extended missions and archival data analysis programs. The selections from the Step-1 proposals were made primarily on the merit of the baseline proposed science; no prejudice or commitment to any attendant proposed SEO activity was made at selection. It is incumbent upon investigation teams, therefore, to fully discuss these project additions in the CSR.

All APEX missions will include a General Observer/ Guest Investigator programs, as applicable. In addition all launched missions will be considered for extended missions as part of SMD's triennial Senior Review process. Consequently, SEOs will only need to be described in Concept Study Reports if they are atypical (*e.g.*, a complementary ground campaign, complementary observations by other NASA observatories).

Funding for SEO activities are outside the AO Cost Cap, and will therefore result in a separate decision by NASA as to whether to accept or reject these proposed expansions to the Baseline Science Mission. Therefore, the CSR must provide sufficient clarity to allow contractual execution if NASA elects to fund any SEO activities.

All definitions, guidelines and constraints outlined in the AO and applicable to SEOs are still valid for the concept study. There are no page count limits for narrative descriptions, rationale, and data for these enhancements, but conciseness and brevity are encouraged.

**Requirement CS-91** If applicable, this section shall provide sufficient data and justifications to enable analysis of not only the science value of the concept, but also its viability and cost. This section shall also provide a cost estimate for performing any SEO activities. In completing the Cost section, the guidelines for Phases B through D apply. Complete a one-page summary of costs using the format shown using the format of Cost Table Template 7. Also, include the total amount in the SEO line item at the bottom of the table in Requirement CS-81 (Cost Table Template 3). Include a discussion of the estimating techniques used to develop the cost estimates.

## **L. CSR APPENDICES**

The following additional information is required to be supplied with the CSR. This information is to be provided in the form of appendices to the CSR, and, as such, will not be counted within the specified page limit.

#### L.1 Letters of Commitment

Requirement CS-92 Letters of commitment signed by officials authorized to commit the resources of the respective institutions or organizations shall be provided from (i) all organizations offering contributions of goods and/or services (including Co-I and Collaborator services, both U.S. and non-U.S.) on a no-exchange-of-funds basis, including all non-U.S. organizations providing hardware or software to the investigation; and (ii) all major or critical participants in the mission regardless of source of funding. Personal letters of commitment signed by the individual shall be provided from (iii) every Proposal Team member as defined in Section 5.8.2 of the AO. Critical participants are those participants (organizations and individuals) who are assigned tasks considered by the PI to be critical to the success of the mission, including those who provide unique required services. All other participants are non-critical. See AO Section 5.8.1 for detailed definitions of (i), (ii), and (iii). Note that participants may fall under multiple headings, in which case, provide a letter of commitment for each applicable heading. If the use of NASA-provided communication or navigation services is proposed, this appendix shall include an associated letter of commitment.

Requirement CS-93 This appendix shall include letters of commitment from non-U.S. individuals and/or institutions that are team members or contributors to APEX investigations. These letters of commitment shall provide evidence that the non-U.S. institution and/or government will commit the appropriate technical, personnel, and funding resources to the proposed investigation if selected by NASA. Such commitments shall be submitted no later than the Site Visit.

The requirements referenced in Section 5.8.1 of the AO apply to institutional letters of commitment. Letters of commitment provided for the Step-1 proposal can be reused if the description of the commitment is unchanged and if the letter of commitment meets the requirements for letters of commitment for the Concept Study Report.

#### L.2 Relevant Experience and Past Performance

In evaluating the CSR, NASA will consider the past performance of the major partner organizations. The evaluation of past performance will not be arithmetic; instead, the information deemed to be most relevant and significant will receive the greatest consideration. Relevant experience will be viewed as the demonstrated accomplishment of work, which is comparable or related to the objectives of the CSR. This includes space-based instrument development and investigations and associated development processes including engineering processes, management processes, operations, data analysis and delivery of data to appropriate data archives. NASA will review the past performance information provided by the proposer. In addition, NASA may review the major team partners' past performance on other NASA and/or non-NASA projects or contracts that provide insight into those institutions' past performance on airborne or space-based instrument development and investigations and associated development processes including engineering processes, management process, operations, data analysis and

delivery of data to the appropriate data archive. In conducting the evaluation, NASA reserves the right to use all information available.

Requirement CS-94 This appendix shall describe relevant experience and past performance by the major team partners (organizations) in meeting the requirements of projects similar to the subject of the CSR. This may include space-based instrument development and investigations. The discussion of relevant experience and past performance shall include: (i) a description of each project; (ii) its relevance to the subject of the CSR; (iii) the proposed performance and the actual performance; (iv) the planned delivery schedule of data to the appropriate data archive and the actual delivery schedule of data to the appropriate data archive; (v) the proposed cost and actual cost; (vi) the proposed schedule and actual schedule; (vii) an explanation of any differences between proposed performance, cost and schedule and what was actually achieved; and (viii) points of contact for the past project's customer. If the customer for the past project was the United States Government, then the contract number must be included along with current technical point(s) of contact and phone number(s). For projects that are not yet complete, the current projected performance, cost, and schedule must be used in place of actual values. Projects that ended more than 5 years ago need not be included.

Investigation teams are cautioned that omissions or an inaccurate or inadequate response to this evaluation item will have a negative effect on the overall evaluation, and while NASA may consider data from other sources, the burden of providing relevant references that NASA can readily contact rests with the investigation team.

### L.3 Resumes

Requirement CS-95 This section shall include resumes or curriculum vitae for the PI, DPI if one is named, PM, PSE, any other named Key Management Team members identified in the Management section, and all Co-Is identified in the Science section. Specifically, each resume shall cite the individual's experience that is pertinent to the role and responsibilities that she/he will assume in the proposed investigation. Project management experience shall be included in the resumes of the PI, PM, and PSE. Resumes or curriculum vitae shall be no longer than three pages for the PI and one page for each additional participant.

### L.4 Phase B Contract Implementation Data

This appendix specifies the data necessary for the Explorers Program Office to modify the contract during the first Bridge Phase in order to add the balance of Phase B activities to the contract. Provision of Phase B contract implementation data may be deferred to the date of each concept study team's Site Visit.

Requirement CS-96 This appendix shall provide cost and pricing data for Phase B that meet the requirements of the FAR Part 15 Table 15-2. These cost and pricing data are necessary and required to implement the contract. Complete cost or pricing data shall be included with the CSR for each organization participating in Phase B, and must be signed by each organization's authorized representative. This requirement may be satisfied with one form, provided that all institutions involved in Phase B are included and have provided the appropriate signatures. These data are in addition to the data provided in Cost Tables Templates 1-7 for evaluation purposes,

and allocate project costs per the cost categories defined in Table 15-2, but still align at the highest levels with the evaluation data. Also see Section J of PART II above for additional guidance.

Requirement CS-97 This appendix shall provide draft SOWs for all potential contracts with NASA. SOWs shall be provided for each contract phase (*i.e.*, Phases B through F) and shall clearly define all proposed deliverables (including science data) for each option, potential requirements for Government facilities and/or Government services, and a proposed schedule for the entire mission.

#### L.5 Open Science and Data Management Plan

Requirement CS-98 This appendix shall provide a discussion of all plans (schedules, costs, and deliverables) and their approach and commitment to delivering project data and scientifically useful software to the appropriate NASA data archives, and indicate such in the plans and schedules for Phase B. This discussion shall also provide assurance that all activities (“womb to tomb”) have been considered and included with separate allocation and budgeting of appropriate resources.

#### L.6 Incentive Plan(s)

Requirement CS-99 If applicable, this appendix shall provide draft incentive plans. Incentive plans must outline contractual incentive features for all major team members. Incentive plans must include both performance and cost incentives, as appropriate.

#### L.7 Technical Content of any International Agreement(s)

Requirement CS-100 Draft language for the technical content of any International Agreement(s) is required for all non-U.S. partners in the investigation. Sample agreements are available in the Program Library. The draft language must include: (i) a brief summary of the mission and the foreign partner’s role in it; (ii) a list of NASA’s responsibilities within the partnership; and (iii) a list of the non-U.S. partner’s responsibilities within the partnership. Note that NASA prefers to establish agreements with foreign Government funding agencies, and not with the institution that will be funded to perform the work.

#### L.8 International Participation Plans (Update from Proposal)

Requirement CS-101 If the investigation includes international participation, either through involvement of non-U.S. nationals and/or involvement of non-U.S. entities, this section shall describe any updates to plans for compliance with U.S. export laws and regulations; *e.g.*, 22 CFR 120130, et seq. and 15 CFR 730-774, et seq., that were provided in the Step-1 proposal (see Appendix B, Section J.5 in the AO). The discussion shall describe in detail the proposed international participation and shall include, but not be limited to, whether or not the international participation may require the proposer to obtain the prior approval of the Department of State or the Department of Commerce via a technical assistance agreement or an export license or whether a license exemption/exception may apply. If prior approvals via licenses are necessary, discuss whether the license has been applied for or, if not, the projected



timing of the application and any implications for the schedule. Information regarding U.S. export regulations is available at [http://www.pmdtc.state.gov/ddtc\\_public](http://www.pmdtc.state.gov/ddtc_public) and <http://www.bis.doc.gov/>. Investigation teams are advised that under U.S. law and regulation, spacecraft and their specifically designed, modified, or configured systems, components, parts, *etc.*, such as instrumentation responsive to the AO, are generally either considered “Defense Articles” on the United States Munitions List and subject to the provisions of the International Traffic in Arms Regulations (ITAR), 22 CFR 120-130, et seq.; or otherwise controlled under the Export Administration Regulations (EAR), 15 CFR parts 730–774, issued by the United States Department of Commerce, Bureau of Industry and Security (BIS) under laws relating to the control of certain exports, reexports, and activities.

#### L.9 Limiting the Generation of Orbital Debris and End-of-Mission Plan

This appendix is required only for missions conducting significant operations or ending their mission life in Low Earth Orbit (LEO) (< 2000 km perigee), near Geosynchronous Orbit (GEO) (GEO  $\pm$  300 km), or at the Moon (lunar orbiters, impactors, or landers) or near Lagrange points.

Per NPR 8715.6B, *NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments*, orbital debris is defined as any object placed in space by humans that remains in orbit, and no longer serves any useful function. Objects range from spacecraft to spent launch vehicle stages to components, and also include materials, fragments, or other objects which are intentionally or inadvertently cast off or generated.

Every selected investigation team must conduct a formal assessment during Phase A of the orbital debris the spacecraft or instrument will create upon mission termination.

For missions traveling beyond Earth orbit, plans for conducting these assessments are required at the end of Phase A only for missions where the mission approach (either during nominal operations, in the event of an anomaly, or at the end of mission) indicates that the likelihood of generating orbital debris in the locations described above is high during nominal operations.

Requirement CS-102 This section shall discuss briefly how the mission meets the NPR 8715.6B and NASA-STD-8719.14C orbit debris requirements applicable to its proposed orbit. For LEO missions, this section shall briefly discuss the lifetime of the mission and whether it meets the 25-year postmission requirement. An orbital lifetime analysis addressing all assumptions and inputs contributing to the analysis shall be provided and describe, at a minimum:

- Vehicle Mass
- Drag Area or Cross-sectional Area
- Initial orbit used for the analysis
- Solar and atmospheric conditions assumptions (*i.e.*, models or parameters)
- Methodology: analytical tool, table lookup, reference plot.

Requirement CS-103 This section shall discuss briefly how the mission meets the NID 7120.132 conjunction assessment and collision avoidance requirements applicable to its proposed orbit. The discussion shall include, at a minimum:

- Schedule and plans for development of an Orbital Collision Avoidance Plan (OCAP) and Conjunction Assessment Operations Implementation Agreement (CAOIA),
- Plans and cadence for production of spacecraft ephemerides and their delivery to CARA,
- Plans and cadence for maneuver notifications to CARA and for pursuing close approach mitigations as needed.

#### L.10 Compliance with Procurement Regulations by NASA PI Proposals

This appendix is required only for CSRs submitted by NASA PIs or NASA Centers (excluding JPL). CSRs submitted by NASA Centers must comply with regulations governing proposals submitted by NASA PIs (NFS 1872.306).

Requirement CS-104 For NASA Center CSRs, this section shall include any descriptions, justifications, representations, indications, statements, and/or explanations that are required by the regulations.

#### L.11 Master Equipment List

Requirement CS-105 This section shall include a Master Equipment List (MEL) in a table summarizing all flight element subsystem components and individual instrument element components to support validation of proposed mass estimates, power estimates, contingencies, design heritage, and cost. Fully contributed instruments should include enough subsystem detail to support validation of instrument design. A template for this MEL is included as Table B5 of the AO, and in the Program Library.

The breakouts should be traceable to block diagrams and heritage claims provided in other parts of the proposal. For each major component, current best estimates (CBE) and contingency for mass and power, number of flight units required, and some description of the heritage basis must be provided. Power values should represent nominal steady state operational power requirements. Information to be provided includes identification of planned spares, identification of engineering models and prototypes with their fidelities, required deliveries for simulators and testing, contingency allocations for individual components, and other component description/characteristics. Certain items should include additional details sufficient to assess functionality and/or cost, to identify and separate individual elements.

List each electronic board separately, identify the functionality of each board (either in the MEL or in the Mission Implementation section), and provide the speed the board will be running at. If proposing Field Programmable Gate Arrays (FPGAs) or Application Specific Integrated Circuits (ASICs), or Radio Frequency Integrated Circuits (RFICs), list the design size (in the appropriate sizing parameter such as logic cells, logic elements), the board the chip(s) will be integrated onto, and how much heritage will be used in the design.

Requirement CS-106 The MEL shall be additionally provided in Microsoft Excel format with the electronic submission.

## L.12 Heritage

**Requirement CS-107** This section shall discuss each element of any heritage from which the proposed investigation derives substantial benefit, including heritage from spacecraft subsystems, instruments, ground systems, flight and ground software, test set ups, simulations, analyses, *etc.* This discussion shall be at an appropriate level of granularity (*e.g.*, component, assembly, subsystem) to clearly separate the heritage element from other elements of the design. The *discussion* of each element shall include:

- A concise description of the design heritage claimed;
- A description of changes required to accommodate project-unique applications and needs;
- Anticipated benefits to the proposed investigation;
- A brief rationale supporting the claim that the benefits of heritage will be achieved; and
- For any proposed elements with substantial design heritage, a comparison of the cost of the heritage items to the proposed cost.

CSRs shall substantiate all heritage claims, including descriptions of changes required to accommodate project-unique applications and needs. Where enhancements to heritage elements are proposed or heritage is from a different application, sufficient descriptions must be provided to independently assess the current level of maturity.

The evaluation team will use a scale with three levels (full, partial, or none) as illustrated in the table below.

	<b>Full heritage</b>	<b>Partial heritage</b>	<b>No heritage</b>
<b>Design</b>	Identical	Minimal modifications	Major modifications
<b>Manufacture</b>	Identical	Limited update of parts and processes necessary	Many updates of parts or processes necessary
<b>Software</b>	Identical	Identical functionality with limited update of software modules (<50%)	Major modifications (≥50%)
<b>Provider</b>	Identical provider and development team	Different however with substantial involvement of original team	Different and minimal or no involvement of original team
<b>Use</b>	Identical	Same interfaces and similar use within a novel overall context	Significantly different from original
<b>Operating Environment</b>	Identical	Within margins of original	Significantly different from original
<b>Referenced Prior Use</b>	In operation	Built and successfully ground tested	Not yet successfully ground tested

Requirement CS-108 If a CSR claims any heritage from which the proposed investigation derives substantial benefit, this appendix shall discuss each element to an appropriate level of granularity (*e.g.*, component, assembly, subsystem) to clearly separate the heritage element from other elements of the design.

#### L.13 Classified Materials

See Section 5.8.4 of the AO for options and associated requirements.

#### L.14 Diversity and Inclusion Plan

Requirement CS-109 In support of NASA's core value of Inclusion (see Section E.6), study teams shall include a plan describing how they will create and maintain a diverse and inclusive team. The plan shall:

- Clearly state goals for creating and sustaining a positive and inclusive working environment and describe activities to achieve these goals including:
  - Identifying barriers to creating a positive and inclusive working environment that are specific to the team carrying out the proposed investigation;
  - Addressing ways in which the investigation team will work to attenuate or reduce these barriers, such as fostering communication and openness amongst the team, accounting for power dynamics to support the team (*e.g.*, awareness of positionality affecting the behaviors team members), elevating voices, *etc.*, to create and sustain an inclusive environment;
- Describe any training that the team would participate in (*e.g.*, bystander intervention training, micro-aggression awareness training, *etc.*) to equip and train team members in such a way that they can go on to lead and contribute to other teams that are inclusive;
- Describe any formal mentoring or professional development activities to be offered;
- Describe any agreements among the team members to be developed such as an Agreement on Acceptable Behavior; and
- Describe quantitative and/or qualitative approaches for assessing the success of these activities including any planned surveys or formal evaluations

It is expected that CSRs will tailor their Diversity and Inclusion Plan specifically to barriers the team is aware of that they will/may encounter during the proposed work, rather than to generic issues surrounding inclusion; inclusion plans are not intended to address barriers in the broader STEM community that are not expected to be encountered by the proposing team.

Study teams are encouraged to leverage institutional resources when available, but if the plan includes a restatement of policies of the host institution, it shall also provide a clear discussion of how these policies connect to the proposed investigation and proposal team. Finally, a Diversity and Inclusion Plan is not the same as public engagement efforts or simply team-building exercises. The plan shall not exceed five pages.

#### L.15 Small Business Subcontracting Plan

Requirement CS-110 A small business subcontracting plan covering Phases B through F, including the proposed goals and targets and the quality and level of work that will be performed by various categories of small business concerns, as described in Section 5.5.1 of the AO, shall be provided, with the exception of separately identifying and being evaluated on participation targets of Small Disadvantaged Businesses (SDBs) in North American Industry Classification System (NAICS) codes determined by the Department of Commerce to be underrepresented industry sectors. Its effect on the technical, management, and cost feasibility of the investigation shall be described. This plan will be negotiated prior to any Phase B contract award.

#### L.16 Additional Cost Data to Assist Validation (Optional)

In addition to the specific cost table data requested in the Cost Proposal (Section J), investigation teams may also provide any additional costing information/data that they feel will assist NASA to validate the project's proposed costs. Vendor quotes, cost estimates, rationale for design heritage cost savings, are all examples of data that can be included here. Input and output files for any publicly available cost model may be included with each electronic submission, if accompanied by discussion in this appendix.

The information provided may include cost by NASA fiscal year to the lowest level of detail the project is working with, in Microsoft Excel format.

#### L.17 Science Change Matrix

Requirement CS-111 If the Phase A effort results in changes from any science objective proposed in Step 1, this appendix shall provide a table with the following columns: the original objective, the new or revised objective, rationale for the change, and the section/paragraph in the CSR where the change occurs. This appendix shall also include changes to the potential scientific value of GO/GI programs.

#### L.18 Communications Design Data

Requirement CS-112 Provide data and detailed link analyses for all communication modes, adequate to assess the design of the communications concept. This shall include a communications block diagram (showing all components) and link budget design control tables for all radio communications links (data and carrier) showing relevant spacecraft and earth station parameters and assumptions for the highest data rate and the emergency link at the maximum distance and throughput at which each particular link could be used. In particular the following parameters shall be provided: Transmitter RF Output Power, Transmitter Antenna Gain, Transmitter Off-Boresight Pointing Loss, Transmitter Circuit Loss, Carrier Frequency, Transmitter-Receiver Range, Receiver Antenna Gain, Receiver Off-Boresight Pointing Loss, Receiver Circuit Loss, Receiver Bandwidth, Receiver System Temperature, Hot Body Noise Temperature, Data Modulation Index, Ranging Modulation Index, Data Rate, Forward Error Correcting Code including code rate, block size (if applicable), constraint length (if applicable), Carrier Modulation Index, Carrier Link Margin, and Data Link Margin. For more information on

these requirements, including table format, see *NASA's Mission Operations and Communication Services*, available in the Program Library.

#### L.19 Space Systems Protection

Requirement CS-113 This Appendix shall provide plans addressing the protection of uplink commands using approaches compliant with FIPS 140-2 Level 1.

Requirement CS-114 This Appendix shall provide plans addressing the ability of command uplink, position, navigation, and timing subsystems to recognize and survive interference.

Requirement CS-115 This Appendix shall provide plans addressing the protection of command uplink information at no less than the CUI level.

Requirement CS-116 This appendix shall demonstrate that adequate resources (including, but not limited to, cost, schedule, technical accommodation, *etc.*) have been allocated to comply with NASA-STD-1006A including generating of a Project Protection Plan (PPP) by PDR and addressing associated Candidate Protection Strategies.

#### L.20 Cybersecurity

Requirement CS-117 This Appendix shall provide a ground system data flow diagram showing end-to-end flows of all mission data, including any flows to facilities outside the control of the mission itself.

Requirement CS-118 This Appendix shall describe plans to develop a System Security Plan using the NIST 800-53 controls as a basis, and demonstrate that adequate resources (including, but not limited to, cost, schedule, technical accommodation, *etc.*) have been allocated to develop and implement this plan.

*Questions concerning Cyber Security may be addressed to: Mr. Reynaldo Anzaldua, SMD Information Security Executive, E-mail: reynaldo.anzaldua@nasa.gov.*

#### L.21 Draft Mission Definition Requirements Agreement

Requirement CS-119 A draft Mission Definition Requirements Agreement (MDRA) shall be provided. MDRA's define Level 2 requirements for the baseline mission, encompassing the programmatic, science and instrument, mission implementation and spacecraft, and ground data requirements. An example MDRA is provided in the Program Library.

#### L.22 Draft MAIP and MAR Compliance Matrix

Requirement CS-120 This section shall provide a draft Mission Assurance Implementation Plan (MAIP) and Compliance Matrix for the *Explorers & Heliophysics Projects Division (EHPD) Mission Assurance Requirements (MAR) Mission Risk Classification – Class C* document in the Program Library.

#### L.23 Justification for the use of non-AMMOS MOS/GDS Tools

Requirement CS-121 This section shall describe the justification for using MOS/GDS tools other than those available from the AMMOS. For each non-AMMOS tool, this section shall contain:

- 1) A list of requirements that the equivalent AMMOS tool does not meet for the proposed flight project; and,
- 2) the proposed non-AMMOS tool that satisfies the listed requirements.

If an AMMOS tool will meet the flight project requirements, this section must outline the reasons for not using that tool (*e.g.*, cost of mission-specific adaptations to the AMMOS tool, extensive heritage of use of the non-AMMOS tool by the mission operator).

#### L.24 Acronyms and Abbreviations List

Requirement CS-122 This section shall provide a list of abbreviations and acronyms.

#### L.25 References and Management Standards List

CSRs may additionally provide, in this appendix, a list of other reference documents and materials used in the concept study. The documents and materials themselves cannot be submitted, unless they are within the CSR's page limit. Investigation teams are encouraged to include an active URL for those documents available through the Internet. If the URL is password protected, provide the password in the CSR.

In addition, if the CSR proposes to use internal program and project management standards, then this section must provide those standards.

Requirement CS-123 This section shall provide a list of any internal program and project management standards to be used in the proposed development (*e.g.*, GEVS, "GOLD Rules"). To the extent practicable, the referenced documents shall be included with the electronic submission.

### **PART III – OTHER FACTORS REQUIRED AFTER DOWN-SELECTION**

#### **Education Program Plan, and Communications and Outreach**

Among NASA's strategic goals is to communicate the results of its efforts to the American public and to enhance the science and technical education of the next generation of Americans. However, Education Program plans are not needed at this time. NASA may impose Education Program requirements during or subsequent to the Phase A concept study phase and will negotiate any additional funding necessary to meet these requirements.

A Communications and Outreach Program (previously referred as Public Outreach) must be developed during Phase B of the mission. The plan must include topline messaging, target audiences, and media processes linked to reaching target audiences. Mission-related communications will be negotiated and funded directly through a NASA Center and are not within the PIMMC.